



EasyGrantsID: 43345

National Fish and Wildlife Foundation – Hurricane Sandy Coastal Resiliency Competitive Grants

Program 2013, Full Proposal

Title: Building Coastal Resilience Brewster, Cape Cod,Massachusetts

Organization: Town of Brewster, Massachusetts

Grant Information

Title of Project

Building Coastal Resilience Brewster, Cape Cod,Massachusetts

Total Amount Requested	\$ 1,867,749.56
Matching Contributions Proposed	\$ 101,000.00
Proposed Grant Period	11/21/ 2014 - 11/11/ 2016

Project Description

Building coastal resilience through planning, managed retreat and relocation of infrastructure; conduct beach and saltmarsh restoration; install green infrastructure in Brewster, Massachusetts

Project Abstract

In order to increase the resiliency of its natural coastal systems and community to the impacts of coastal change and sea level rise, the Town of Brewster, Massachusetts is proposing to: (1) Develop a comprehensive coastal resiliency plan that incorporates sound science and appropriate design; (2) Implement two coastal restoration and three green infrastructure projects at public access locations to address existing resource impacts from storm events, and (3) Engage citizens to increase their understanding of the value to coastal retreat and restoration of natural resources for fisheries and wildlife habitat and for coastal adaptation.

Project outcomes are: (1) better coordinated and integrated investments and regulations that promote coastal resiliency and resource restoration; (2) development of public facilities that contribute to coastal resiliency and restoration of natural resource ecosystem services and (3) use of green technologies to improve and protect wildlife habitat and the natural resiliency of coastal resources.

Organization and Primary Contact Information

Organization	Town of Brewster, Massachusetts
Organization Type	State or Local Government
Organization Web Address	www.town.brewster.ma.us
Organization Phone	
Street Line 1	
Street Line 2	

City, State, Country, Postal Code	Brewster,Massachusetts,North America - United States
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Region (if international)

Organization Congressional District	District 9 (MA)
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Primary Contact

Position/Title	Mr. Christopher John Miller
Street Line 1	Director of Natural Resources
Street Line 2	Brewster Department of Natural Resources
City, State, Country, Postal Code	2198 Main Street
	BREWSTER, Massachusetts, North America - United States, 02631



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Organization: Town of Brewster, Massachusetts

Region (if international)

Phone and E-mail

508-896-3701 x ; cmiller@town.brewster.ma.us

Keywords

Conservation Action; Conservation Threat

Sub-keywords

Action - External Capacity Building; Action - Land/Water Management;
Action - Land/Water Protection; Threat - Climate Change & Severe
Weather; Threat - Human Intrusions & disturbance; Threat -
Residential & Commercial Development

Other Keyword(s)



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Project Location Information

Project Location Description	Brewster, Massachusetts, in Barnstable County. Located on the north side of Cape Cod along Cape Cod bay.
Project Country(ies)	North America - United States
Project State(s)	Massachusetts
Project Congressional District(s)	District 9 (MA)

Permits and Approvals

Permits/Approvals Description:	Notice of Intent with local Conservation Commission, acting as agent for the state. Individual permits needed for all implementation projects; Bettys Curve, Mants Landing, Oyster Reef, Breakwater Landing.
Permits/Approvals Status:	Intend to Apply

Permits/Approvals Agency-Contact Person:	James Gallagher, Brewster Conservation Administrator
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Permits/Approvals Submittal-Approval Date:	11/21/2014 12:00:00 AM
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Permits/Approvals Description:	Permit with State Historical Commission 950 CMR: OFFICE OF THE SECRETARY OF THE COMMONWEALTH. Will notify them with submittal of the Notice of Intent to the conservation commission.
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Permits/Approvals Status:	Intend to Apply
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Permits/Approvals Agency-Contact Person:	Dennis Fiori
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Permits/Approvals Submittal-Approval Date:	11/21/2014 12:00:00 AM
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Permits/Approvals Description:	Old Kings Highway Historic District permit needed as all projects are within their jurisdiction. Permits will be submitted with Order of Conditions to conservation.
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Permits/Approvals Status:	Intend to Apply
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Permits/Approvals Agency-Contact Person:	John Halvorson, Chair, Brewster Old Kings Highway Historic District
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Permits/Approvals Submittal-Approval Date:	11/21/2014 12:00:00 AM
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Permits/Approvals Description: Massachusetts Department of Transportation - Highway Division.
State highway permit for work within Rt. 6a at Betty's Curve. Will
be prepared by project engineer during design phase of project.

Permits/Approvals Status: Intend to Apply

Permits/Approvals Agency-Contact Person: Frank DePaola, P.E. Highway Administrator MassDOT

Permits/Approvals Submittal-Approval Date: 4/10/2015 12:00:00 AM

Permits/Approvals Description: Massachusetts Division of Marine Fisheries special aquaculture
permit for a pilot oyster reef.

Permits/Approvals Status: Intend to Apply

Permits/Approvals Agency-Contact Person: Mike Hickey, Shellfish Program Manager

Permits/Approvals Submittal-Approval Date: 1/30/2015 12:00:00 AM



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Salaries and Benefits

	Units	Cost Per Unit	Total
Student Interns for monitoring	2	\$14,420.00	\$28,840.00

Total Salaries and Benefits			\$28,840.00
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We will hire two college students studying for an environmental degree who are interested in field experience. Primary tasks will be implementation and monitoring of the oyster reef project, and plantings and restoration work at the managed retreat sites (Breakwater and Mants Landings). Additional tasks will be documentation of project tasks via photographs and a regularly updated and public website, and coordination and participation in public outreach events.

The Town will provide training and supervision, plus provide seasonal housing for the two interns, and the grant will provide wages and reimbursement for expenses.

Seasonal Internship:

4 months per year (14 weeks) for two years, two interns, 35 hours per week = 1960 hours.

Hourly rate used would be \$14/hour with housing provided by the town as match.

Wages \$27,440

Mileage/expenses stipend = \$1400 (\$25/week per intern)

Equipment

	Units	Cost Per Unit	Total

Total Equipment			\$0.00
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Contractual Services

	Units	Cost Per Unit	Total
Mants Landing Engineering	1	\$85,000.00	\$85,000.00
Mants Landing Construction	1	\$437,923.00	\$437,923.00
Breakwater Landing Engineering	1	\$39,000.00	\$39,000.00



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	Units	Cost Per Unit	Total
Breakwater Landing Construction	1	\$180,625.75	\$180,625.75
Bettys Curve Stormwater Engineering	1	\$90,000.00	\$90,000.00
Bettys Curve Stormwater Construction	1	\$410,000.00	\$410,000.00
Oyster Reef Design/build	1	\$38,200.00	\$38,200.00
Oyster Reef Construction	1	\$200,000.00	\$200,000.00
Monitoring	1	\$53,000.00	\$53,000.00
Federal Audit	2	\$5,000.00	\$10,000.00
Project Manager	1	\$50,000.00	\$50,000.00
Sediment Budget	1	\$52,660.81	\$52,660.81
Coastal Resiliency Plan Development	1	\$192,500.00	\$192,500.00

Total Contractual Services			\$1,838,909.56
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The Town of Brewster will select engineering firm(s) to prepare plans, permit applications and provide engineering services. The Town will seek a professional services contract to manage the development of the Brewster Coastal Resiliency Plan. The Town will execute separate agreements with PCCS to conduct Task 1.1 and with APCC to conduct salt marsh monitoring (Task 2.4); these services are exempt from the state procurement process, which will expedite selection and allow the Town to meet the schedules proposed in this grant application. The Town will bid construction tasks under Massachusetts General Law Chapter 30 Section 39 M (Public Works, non-building) construction.

Supplies and Materials

	Units	Cost Per Unit	Total

Total Supplies and Materials			\$0.00
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Printing



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	Units	Cost Per Unit	Total

Total Printing			\$0.00

Travel

	Units	Cost Per Unit	Total

Total Travel			\$0.00

Other

	Units	Cost Per Unit	Total

Total Other			\$0.00

Budget Grand Total			\$1,867,749.56
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Matching Contributions

Matching Contribution Amount:	\$8,000.00
Type:	In-kind
Status:	Pledged
Source:	Town of Brewster
Source Type:	Non-Federal
Description:	Summer housing for two interns for two years.
Matching Contribution Amount:	\$11,000.00
Type:	In-kind
Status:	Pledged
Source:	APCC and the Mass Bays Program
Source Type:	Non-Federal
Description:	Funding for an APCC staff to assist the Town with project management and outreach.
Matching Contribution Amount:	\$10,000.00
Type:	In-kind
Status:	Pledged
Source:	APCC
Source Type:	Non-Federal
Description:	APCC staff will provide in-kind services to monitor restored beaches and dunes and to monitor salt marsh.
Matching Contribution Amount:	\$72,000.00
Type:	In-kind
Status:	Pledged
Source:	Town of Brewster
Source Type:	Non-Federal
Description:	Chris Miller, Director of the Natural Resources Department as the project team leader for the Town (2000 hours/\$44,000). 600 hours of volunteer time (\$22/hr) \$13,200. Other staff, Public Works Super., Town Administrator, Town Planner, Conserv. admin
Total Amount of Matching Contributions	\$101,000.00



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Activities and Outcomes

Funding Strategy: Species Outcome

Activity / Outcome: Sandy - American Oyster - Population - Acres occupied by the species

Description: Enter the number of acres of habitat occupied by the species

Required: Recommended

Acres occupied by the species - Current: 11

Acres occupied by the species - Grant Completion: 12

Notes: Establishment of a pilot 1000 foot oyster reef to protect a critical salt marsh, and increase biodiversity. When the reef is fully established additional areas of town will receive spat from the mature breeding oysters, further expanding the native oyster population in town waters.

Funding Strategy: Species-specific Strategies

Activity / Outcome: Sandy - American Oyster - Translocation - # translocated/stocked

Description: Enter the number of individuals translocated or stocked

Required: Recommended

translocated/stocked - Current: 500000

translocated/stocked - Grant Completion: 800000

Notes: The Town of Brewster grows approximately 500,000 oysters each year for public harvest (aquaculture). Establishing a new reef will allow additional oysters to be harvested from the wild once it is fully established.

Funding Strategy: Habitat Restoration

Activity / Outcome: Sandy - Beach habitat quality improvements - Acres restored

Description: Enter the number of acres restored

Required: Recommended

Acres restored - Current: 1.00

Acres restored - Grant Completion: 6

Notes: The Town of Brewster recently restored a former parking area to natural beach and dune at Paines Creek as a part of an ARRA funded stormwater project. We are proposing a coastal retreat project at Breakwater Landing, restoring former asphalt parking areas to dune, as well as a resiliency project in a coastal dune at Mants Landing. The Oyster Reef pilot project will also protect 1000 feet of coastal dune, beach and 5.5 acres of fronting saltmarsh.

Funding Strategy: Habitat Restoration

Activity / Outcome: Sandy - Beach habitat quality improvements - Miles restored

Description: Enter the number of miles restored



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Required: Recommended

Miles restored - Current: 0

Miles restored - Grant Completion: 0.5

Notes: The proposed oyster reef pilot project will protect 1000 feet of salt marsh, coastal beach and dune. In addition, the coastal retreat project at Breakwater will restore 300 feet of beach and dune. The resiliency project at Mants will remove asphalt from a coastal dune/beach and allow measured retreat over time.

Funding Strategy: Habitat Restoration

Activity / Outcome: Sandy - Erosion control - # structures installed

Description: Enter the number of structures installed, replaced, upgraded or repaired to reduce erosion or wetland/marsh lost.

Required: Recommended

structures installed - Current: 4

structures installed - Grant Completion: 7

Notes: The pilot 1000 foot oyster reef project will limit erosion and loss of salt marsh fronting a coastal beach and dune. At Breakwater we are installing sturdy sand drift fencing to build and protect the facing coastal dune, and proposing a coastal retreat of a paved parking lot, with restoration to dune habitat. At Mants Landing, we are proposing to remove an asphalt parking lot that is regularly inundated by coastal storms with a resilient permeable articulating concrete mat. This will reduce erosion of the parking area and allow for a measured retreat by removing sections as the beach front erodes. We are adding sacrificial dunes at several smaller coastal access points across town.

Funding Strategy: Habitat Restoration

Activity / Outcome: Sandy - Floodplain restoration - Acres restored

Description: Enter the number of acres restored

Required: Recommended

Acres restored - Current: 64

Acres restored - Grant Completion: 65

Notes: We have removed coastal restrictions to salt marshes at four locations in town, restoring 64 acres of salt marsh by installing appropriately sized culverts. At Betty's Curve on Rt. 6a, we are proposing to install green stormwater infiltration areas to collect stormwater and treat it through naturally vegetated swales and a constructed wetland. This is within areas of coastal storm flowage and will increase resilience along our coast.

Funding Strategy: Habitat Management

Activity / Outcome: Sandy - BMP implementation for stormwater runoff - Acres under BMPs



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Description: Enter the number of acres under Best Management Practices (BMPs)

Required: Recommended

Acres under BMPs - Current: 10

Acres under BMPs - Grant Completion: 11

Notes: In the last several years we have spent substantial funds on stormwater infrastructure in the Stony Brook Valley. This includes work at the Stony Brook Mill roadway higher in the watershed, plus projects at Paines Creek North, Paines Creek South, Saints Landing, and the coastal retreat project at Paines Creek Beach that reduced stormwater by removing a paved parking area in dune and replaced it with a mostly pervious parking area outside the resource area, with stormwater catch basins and infiltration areas. This work is described in the stormwater report associated with the proposed Bettys Curve green stormwater project. The Bettys Curve project is a key unbuilt portion of this plan, and will use naturally vegetated swales to treat stormwater from local roads and the adjacent state highway that otherwise flows untreated into a coastal salt marsh and fish passage.

Funding Strategy: Capacity, Outreach, Incentives

Activity / Outcome: Sandy - Outreach/ Education/ Technical Assistance - # people reached

Description: Enter the number of people reached by outreach, training, or technical assistance activities

Required: Recommended

people reached - Current: 0

people reached - Grant Completion: 40000

Notes: The town population is approximately 9,000 year round residents, but the summer population swells to over 35,000 people. The planning efforts will include multiple public meetings, a new public committee to deal with long-range coastal adaptation planning, and written reports, including updates to our Hazard Mitigation plan. These outputs will also be shared with neighboring communities and may help guide their planning efforts.

Funding Strategy: Planning, Research, Monitoring

Activity / Outcome: Sandy - Management or Governance Planning - # plans developed

Description: Enter the number of plans developed that had input from multiple stakeholders

Required: Recommended

plans developed - Current: 2.00

plans developed - Grant Completion: 3.00

Notes: The Town has a Hazard Mitigation Plan, and is working on an Integrated Water Planning effort. This grant will produce a Coastal Resiliency Plan that will provide key data for each of these other plans.

Funding Strategy: Planning, Research, Monitoring

Activity / Outcome: Sandy - Research - # research studies completed



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Description: Enter the number of research studies completed

Required: Recommended

research studies completed - Current: 3

research studies completed - Grant Completion: 7

Notes: This project will add four key research studies, to include a sediment budget for our portion of the Cape Cod Bay near coastal waters; a study on salt marshes; a study on the pilot oyster reef; and a monitoring report on restored beaches and dunes at managed retreat sites.

Funding Strategy: Capacity, Outreach, Incentives

Activity / Outcome: Sandy - Volunteer participation - # volunteers participating

Description: Enter the number of volunteers participating in projects

Required: Recommended

volunteers participating - Current: 150

volunteers participating - Grant Completion: 250

Notes: The Brewster Department of Natural Resources has developed a volunteer program under the name Brewster FLATS (Friends of Land, Aquatics, Trails and Shellfish) that currently has 150 active members who assist the department with aquaculture, beach cleanups, public outreach, and other land management tasks. This grant will provide significant new ways for the public to be involved with management and evaluation of our coastal environment and we anticipate a long term increase of 100 additional volunteers.

Funding Strategy: Capacity, Outreach, Incentives

Activity / Outcome: Sandy - Economic benefits - # jobs created

Description: Enter the number of jobs created

Required: Recommended

jobs created - Current: 0

jobs created - Grant Completion: 6

Notes: We anticipate this project will provide the equivalent of at least 6 full time jobs through the grant period.

Funding Strategy: Habitat Management

Activity / Outcome: Sandy - Improved management practices - Acres under improved management

Description: Enter the number of acres under improved management

Required: Recommended

Acres under improved management - Current: 0

Acres under improved management - Grant Completion: 1600



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Notes: We anticipate a minimum of 10% of the town, or 1600 acres, will be under improved management and understanding based on the results of the Coastal Resiliency planning efforts of this grant. This number could be substantially higher if we include the tidally exposed flats that extend up to two miles off shore at low tide, as they are the subject of the sediment budget portion of the study.

Funding Strategy: Capacity, Outreach, Incentives

Activity / Outcome: Sandy - Outreach/ Education/ Technical Assistance - # people with changed behavior

Description: Enter the number of individuals demonstrating a minimum threshold of behavior change

Required: Recommended

people with changed behavior - Current: 0

people with changed behavior - Grant Completion: 500

Notes:



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The following pages contain the uploaded documents, in the order shown below, as provided by the applicant:

GAAP audited financial statements

A-133 Audit

Spatial Data

Statement of Litigation

Board of Trustees, Directors, or equivalent

Letters of Support

Project Map

Conceptual Plans

Engineered Plans

Other Documents

Hurricane Sandy Proposal Narrative

The following uploads do not have the same headers and footers as the previous sections of this document in order to preserve the integrity of the actual files uploaded.

Introduction

The Town of Brewster is pleased to submit this proposal to the National Fish and Wildlife Foundation to reduce the Town's vulnerability to the risks of climate change by strengthening natural ecosystems for the benefit of fish and wildlife and to reduce Brewster's vulnerability. The Town is proposing to conduct an integrated set of projects and is requesting funding under **three funding opportunities** identified in the Request for Proposals:

- Coastal Resiliency Assessments – development of a town-wide coastal resiliency plan
- Restoration and Resiliency Projects - (1) Breakwater parking lot retreat; restoration of beach/dune and installation of green stormwater technologies (2) installation of pilot oyster reef, a living shoreline to protect salt marsh, and (3) Mants parking lot, adaptive management and resilience
- Green Infrastructure - Betty's Curve on Route 6A

These activities leverage prior and other current projects which are identified below.

The Project Team has successfully worked together on other restoration and resource protection projects. The Team has an excellent track record, having both been recognized by the Coastal America Partnership and NOAA for projects in Brewster.

The development of Brewster's coastal resiliency plan is consistent with the goals and approach proposed by the North Atlantic Landscape Conservation Cooperative in two DOI Mitigation Funding projects: Decision Support Tools for Hurricane Sandy Restoration and Future Conservation to (1) Increase Resiliency of Beach Habitats and Beach-Dependent Species and (2) to Increase Resiliency of Tidal Wetland Habitats and Species in the Face of Storms and Sea Level Rise (<http://northatlanticlcc.org/the-cooperative/steering-committee/metting-handouts/november-2013/handout-4a>).

Brewster's restoration projects are also consistent with the goals of the Massachusetts Wildlife Conservation Strategy, including habitat restoration and management, protection of wetlands, and monitoring. (<http://www.mass.gov/eea/agencies/dfg/dfw/wildlife-habitat-conservation/state-wildlife-conservation-strategy.html>)

A. Geographic Context:

The work described in this proposal will be conducted within the boundaries of the Town of Brewster, located on the north side of Cape Cod in the Commonwealth of Massachusetts. The exception is that the sediment budget analysis (Subtask 1.1) will include portions of the shoreline of the Town of Dennis to the west of Brewster, as it is a source of sediment to Brewster's shore, and will extend to the east to encompass Namskaket Creek in the Town of Orleans which is a sediment sink (Berman, 2011). Dennis and Brewster share the Quivett Creek marsh system and Orleans and Brewster share the Namskaket Marsh system.

B. Project Narrative:

a. Project Goals:

The Goals of this project are to:

- (1) Develop a coastal resiliency plan that incorporates sound science and appropriate design to guide Brewster's future investments and actions to address the impacts of climate change;
- (2) Implement coastal restoration and green infrastructure projects to address and reduce the consequences of coastal change and storm events;
- (3) Enhance public support and understanding of the importance coastal retreat and restoration of natural resources by engaging citizens and local and regional organizations.

Proposed Tasks and their objectives:

Task 1. Assessment, planning and design for coastal resiliency: The overall objectives of this task and subtasks are to increase the resiliency of the Town's natural coastal systems and community to sea level rise, coastal erosion, storm damage and flooding by developing a comprehensive Town-wide Coastal Resiliency Plan. Specific activities include:

Subtask 1.1. Assessment of coastal sediment budget to identify resilient coastal habitat: The objective is to determine the resiliency and vulnerability of Brewster's shore and coastal landforms to coastal erosion, sea level rise and flooding. This assessment is a critical building block for the development of adaptation strategies in response to climate change, as sediment is vital to sustaining and preserving the resiliency of coastal landforms, habitat, and ecosystems. Similar scientific surveys have been completed for the Outer Cape and the Cape Cod Bay shore of Provincetown and Truro (Giese et.al, 2011 and Giese,et.al, 2012). [See Other Documents Upload]

Output: A sediment budget that characterizes and quantifies, at a century scale, the sources and sinks of sediment and the volume, rate and direction of sediment movement along the coast. Specific areas of erosion and accretion will be identified.

Subtask 1.2. Plan for restoration of natural systems: The objective is to develop a plan to restore impaired natural coastal systems to increase their coastal resiliency and improve fish and wildlife habitat. Natural systems (e.g., coastal dunes, beaches, coastal banks, salt marshes, tidal estuaries, coastal wetlands, undeveloped coastal floodplain, rare species habitat, open space, water and wetlands) will be identified and assessed for their habitat functionality and role in resiliency.

Output: The identification of restoration needs and/or adaptation or protection measures that will increase resiliency (e.g., open space protection or parcels to acquire to allow for coastal retreat, changes in local bylaws or wetland regulations to improve protection of floodplain resources, identification of tidally-restricted marshes where restoration of tidal flow would benefit coastal habitat as well as resiliency).

Subtask 1.3. Planning and design for managed retreat of public access infrastructure from hazardous coastal areas: This task involves planning and design to relocate public access to Mants Landing Beach, the restored beaches at Linnell Beach and Crosby Beach, the eroding beach at Ellis Landing, and other town beaches which have experienced storm damage. [See Other Document Uploads]. The objective is to plan for managed retreat, restore fish and wildlife habitat, provide sustainable public access that minimizes or avoids impacts on habitat, and reduce the risk of damage and need for continued public investment.

Output: A plan that identifies public access infrastructure to be relocated or made more resilient, alternatives for relocation sites, and a multi-modal plan for public access, both of which will guide the Town's future infrastructure investments.

Subtask 1.4. Planning for the effects of rising sea level on water resources and wetlands: The objective is to identify and plan for the effects of rising sea level on Brewster's water resources, wetlands and habitat. This task leverages a larger study currently underway by Association to Preserve Cape Cod (APCC) and the U.S. Geological Survey to model the effects of sea level rise on the mid-Cape's groundwater system which supports most of the mid-Cape's ponds, lakes and streams. It also leverages the Town's development of an Integrated Water Resources Management Plan to address drinking water, wastewater and stormwater. [See Other Document Upload]

Output: a plan that identifies water resources at risk from rising sea level and adaptation measures to protect water and wetlands habitat and which will be implemented under various Town initiatives.

Subtask 1.5. Coastal Resiliency Plan: The objective is to synthesize the results of assessment and planning Tasks 1.1 through 1.4 and develop a town-wide Coastal Resiliency Plan to increase the coastal resiliency and habitat value of natural resources. . [See Other Document Upload]

Output: a comprehensive plan with recommendations for policies, actions and regulatory changes, and an implementation plan for incorporating measures into the Town's local comprehensive plan, bylaws and policies at multiple levels.

Task 2. Restoration and resiliency projects: The objectives of these on-the-ground restoration projects are to increase coastal resilience and restore fish and wildlife habitat. At each of the project sites, the Town will install

interpretive panels to educate the public about the nature and value of the project. Subtasks include the following:

Subtask 2.1. Relocation of Breakwater Landing Beach parking area and restoration of beach and dune habitat: The objective is to remove the vulnerable portion of the paved town parking lot at Breakwater Landing Beach, restore the coastal beach and dune habitat, build a replacement parking lot using porous pavement at a more inland area, and install green stormwater infrastructure (e.g., vegetated bioretention or vegetated swale) to improve water quality for swimming, shellfishing and habitat. [See Engineered Plans Upload]

Outcomes: removal and relocation of the parking lot, restoration of habitat, and improved water quality.

Subtask 2.2. Adaptive management of Mants Landing Beach parking area: The paved parking area at Mants Landing Beach is located in a dune and suffers from repetitive storm damage. The objective is to test the use of a removable flexible concrete mat, successfully used elsewhere on Cape Cod, as an interim replacement for a paved parking area on a beach until a permanent solution can be found [See Conceptual Plan Upload]

Outcome: Flexible concrete mat utilized at other vulnerable Town beach parking areas until more permanent solutions are identified. If the mat is successful (as measured by public acceptance, reduced need for repairing the parking area after each storm and improved beach and dune habitat as demonstrated by monitoring (see below), it will be installed at Town beach parking areas.

Subtask 2.3. Protecting salt marsh using an artificial oyster reef. The objective of this pilot project is to install an oyster reef as a living shoreline along the seaward margin of a salt marsh to test whether the oyster reef will enhance salt marsh growth and/or protect it from erosion and storm damage. The proposed site is an existing salt marsh located east of Paines Creek Beach estuary, growing seaward into Cape Cod Bay. Artificial oyster reefs to enhance biodiversity have been successfully built on Cape Cod, and a similar approach will be used. The Town will partner with Dr. Mark Faherty from the Wellfleet Audubon Sanctuary, who has successfully built oyster reefs to increase biodiversity. Dr. Faherty will be the technical advisor for this subtask. [See Conceptual Plan Upload] Success will be measured based on monitoring of salt marsh and oyster reef conditions, particularly expansion and enhanced growth of salt marsh following oyster reef installation.

Outcome: If successful, the resiliency of the adjacent salt marsh will be increased and biodiversity enhanced, and the beach, dune and marsh system beyond will receive additional protection.

Subtask 2.4. Monitoring to evaluate success of restoration projects (restored beaches/dunes, salt marsh/oyster reef): The objective is to evaluate the progress and success of restoration at restored sites and to identify any issues that need to be addressed to improve restoration success. Monitoring activities include: 1) monitoring restoration success at restored beaches and dunes, including vegetation, wildlife usage and beach profiles to be done by the Town and its interns and volunteers; 2) monitoring salt marsh at the oyster reef site, including vegetation, salinity, avians and fish, to be done by APCC; and 3) monitoring of stormwater projects (see Task 3, below), including water quality and trapped contaminants, to be done by the Town and its interns and volunteers. [See Other Document Upload]

Outputs: monitoring data and reports for pre-restoration and post-restoration conditions.

Outcomes: For restored beach and dune habitat, measures of success include establishment of native beach and dune vegetation species following two growing seasons, documentation of wildlife utilizing restored habitat, re-establishment of natural sediment transport patterns as demonstrated by beach profiles, photographic documentation and comparison with the pre-restoration modeled sediment budget for the area. For the salt marsh/oyster reef project, measures of success include increased abundance and extent of salt marsh vegetation.

Task 3. Green stormwater infrastructure: The objective is to improve water quality and protect restored beaches, dunes, salt marsh and shellfish habitat and reduce runoff and erosion by installing vegetated stormwater infrastructure (e.g., vegetated bioretention basin, vegetated swale, rain gardens or other green

stormwater infrastructure) at several locations throughout the Town's coastal watersheds. Proposed sites include a site on Stony Brook (Betty's Curve), Breakwater Landing Beach and Mants Landing Beach. [See Engineered Plans Upload]

Outcome: measures of success include an improvement in water quality and trapping of pollutants in stormwater treatment areas.

Task 4. Provide public outreach to build support for proposed and future resiliency measures. The objective is to build citizen support for proposed resiliency measures and for future measures by providing public outreach on the benefits of protecting and restoring natural coastal systems. The Brewster Coastal Committee comprised of seven citizens appointed by the Board of Selectmen will work with the Project Manager and Project Team, reviewing materials and advising on final recommendations of the coastal resiliency plan. Outreach and public information activities will include at least two public informational meetings, field trips to one or more of the restoration sites, press releases, a Town web-page describing the project and progress on specific tasks, public service announcements, and outreach to specific landowner and community groups. Special interpretive signs will be installed at each of the restoration sites to build public understanding about the nature and value of the projects.

Outputs: public stakeholder meetings, webpage, press releases, a Town webpage describing projects and progress, interpretive signs, outreach to specific landowners or community sectors, PSAs via radio, posters and fact sheets

The success of Brewster's coastal resiliency program will be measured by a number of indicators including the following:

- 1) Integration of the coastal adaptation plan into the Town's local comprehensive plan and its long range capital plan, establishing Town policies and departments' priorities for projects and activities in Brewster's coastal zone;
- 2) Successful discussions with the Massachusetts Division of Conservation and Recreation resulting in the development of preliminary design and costs for development of at least one inland public parking area, with ADA-and bicycle access, in the northern section of Nickerson State Park (Crosby Beach area) within the first two years of completing the coastal adaptation plan;
- 3) Restoration of 325 linear feet of beach and dune area at three sites through managed retreat and relocation of susceptible infrastructure;
- 4) Protection and/or expansion of 5.5 acres of salt marsh at the mouth of Paines Creek through the use of an experimental oyster reef;
- 5) Improvement in water quality in receiving bodies and trapping of pollutants in stormwater treatment systems as measured by monitoring;
- 6) Public support for future coastal resiliency and restoration projects, as demonstrated by voter approval of budget requests at Town Meeting.

b. Priority:

In 1985, the Commonwealth of Massachusetts designated the 2,600-acre Inner Cape Cod Bay Area of Critical Environmental Concern (ACEC) after its nomination by the Towns of Brewster, Eastham, and Orleans. The ACEC includes hundreds of acres of salt marsh, highly productive shellfish beds, undisturbed wildlife habitat, rare species habitat, barrier beaches, salt ponds, and tidal creeks. The Town has approximately 450 acres of tidal creeks and marshes with three principal tidal creeks- Quivett and Paines at the west end of town and Namskaket at the east end. At low tide, the sea recedes up to two miles offshore, exposing approximately 12,000 acres of tidal flats in Brewster alone.

The Town's entire coastline is currently in the FEMA VE flood zone and most or all of its tidal marsh and creek system are mapped as AE. In the past five years, extensive parts of coastal Brewster have been exposed to storm surge impacts, including dune washover, flooding and significant erosion. In some areas up to 20 feet of dune/coastal bank have been lost in a single storm event. Brewster has ten (10) public access sites at beaches

along its coast and is facing many management decisions as many are located between a beach/dune area and wetlands. The coastal area is critically important to Brewster's coastal character and economy. We have a number of limited scientific studies that have informed the project concepts and designs presented in this proposal. The Town is proposing to contract for two critical scientific studies (1) development of a sediment budget to identify resilient and vulnerable coastal landforms, using the Center for Coastal Studies methodology and (2) assessing the impacts of sea level rise on groundwater, water and wetlands, using a model developed by the United States Geological Survey; both of which will be incorporated into the town-wide Coastal Resiliency Plan and inform future coastal adaptation, resiliency and restoration priorities and actions.

c. Sustained Benefits:

Brewster citizens will acquire a better understanding of how the Town's coastal resources have evolved and their current and future vulnerabilities to erosion, sea level rise, storms and coastal change.

Other sustained benefits include:

- Less public infrastructure at risk
- Reduced need for continued public investment in hard infrastructure
- Enhanced value of ecosystems services provided by coastal resources
- Guide for public for management of privately owned coastal properties
- Improved water quality and reduction in maintenance costs through implementation of green stormwater infrastructure

d. Leveraging:

- The Town is partnering with the Cape Cod Commission on their proposal to evaluate the Cape-wide vulnerability of infrastructure to coastal change. The Town will coordinate and collaborate with the Commission and other agencies and organizations working on coastal adaptation.
- The coastal sediment budget methodology was initially developed and applied to the Wellfleet and Truro coast of Cape Cod Bay, north of Brewster, with funding from the National Park Service, the Island Foundation and the Massachusetts Bays Program, a partner on this project. This project will provide additional coverage of the shore of Cape Cod Bay.
- Evaluation of impacts of sea level rise on water resources of the mid-Cape aquifer is funded by the Massachusetts Environmental Trust, U.S. Geological Survey, Cape Cod Commission, Massachusetts Department of Environmental Protection, the Nature Conservancy, private foundations, the Mass Bays Program and the Association to Preserve Cape Cod, partners on this project.
- Designation of the Inner Cape Cod Bay Area of Critical Environmental Concern, the highest level designation for coastal resources and includes a voluntary limitation of activities that can be conducted in the area.

The proposed project complements numerous previous Town restoration projects, including:

- Restoration of Stony Brook/Paines Creek watershed to restore 41 acres of tidally-restricted salt marsh, improve habitat for rare salt marsh species (*Spartina cynosuroides*, *Lilaeopsis chinensis*), improve stream flow and fish passage to 386 acres of spawning and nursery habitat for river herring and American eels;
- Restoration of a coastal beach and dune at Paines Creek Beach following removal of a parking area from coastal dune and relocation of the parking area landward; [See Other Document Upload]
- Remediation of stormwater runoff into Stony Brook watershed at Stony Brook Mill, Paines Creek Road, and Paines Creek Beach and development of plans for other sections including the proposed Betty's Curve bioretention project;
- Restoration of 10 acres of tidally-restricted salt marsh at Namskaket Salt Marsh and 10 acres at Quivett Creek Salt Marsh on the eastern and western boundaries of Brewster, respectively;
- Town meeting approval of a zoning bylaw designating a Water Resource Protection District, one of two such zoning bylaws passed on Cape Cod; and
- Collaborating with Brewster Conservation Trust in acquisition of parcels in sensitive environments.

Many agencies and organizations have invested heavily in these projects to protect and restore Brewster's coastal resources. In the last eight years alone, over \$3 million in technical assistance and/or funding has been provided by: Gulf of Maine Council/NOAA Habitat Restoration Grant, NOAA-ARRA Coastal Restoration grant for \$1.6 million, MA Division of Ecological Restoration, MA DEP 319 and MA DEP 604B grants for stormwater, USDA Natural Resources Conservation Service, Cape Cod Conservation District, Mass Bays Program, Association to Preserve Cape Cod, Corporate Wetlands Restoration Program, MA Department of Conservation and Recreation, MA Coastal Zone Management, MA Division of Marine Fisheries, and private foundations.

e. Speed to Functionality:

Brewster is proposing an integrated approach that has varied timeframes for implementation and benefits.

Immediate Benefits:

- Heightened public engagement and awareness. Anyone going to the beach will be able to watch the changes to the parking areas and dune and beach restoration. Volunteers will provide basic information about the projects, emphasizing the importance of planning for climate change and protecting the town's coastal resources from future damage. Informed citizens will be more likely to support budget requests for future coastal resiliency and restoration projects.

Project Timeframe:

- Partial retreat and relocation of infrastructure, dune and beach restoration, and installation of green stormwater technologies will be completed within the project timeframe. Previous dune restoration projects in Brewster have resulted in storm damage prevention benefits within the year at some locations.
- The coastal resiliency plan will take two years to complete; however, the scientific work to be done, i.e., the sediment budget and the evaluation of impacts of sea level rise on groundwater and wetlands, will be available at the start of the second year of the project.

Two Years and Beyond:

- The project activities are expected to yield positive benefits for coastal resiliency and wildlife habitat within two growing seasons
- Benefits of the pilot project to test use of oyster reefs in promoting salt marsh accretion will require evaluation of monitoring results from at least three years of monitoring.
- Benefits from installation of green stormwater infrastructure should be apparent within two years, based on monitoring of water quality and analysis of trapped debris in stormwater structures.

C. Youth and/or Veteran Engagement:

Volunteer engagement: Brewster has an active volunteer group called FLATS: Friends of Lands, Aquatics, Trails and Shellfish, with 150 members from the community. They are young and old, men and women, boy scouts and military veterans, all of whom assist DNR on a variety of coastal projects. DNR also uses summer interns from the local regional high school and Cape Cod Community College.

Youth engagement: The Town proposes to use grant funds to hire two seasonal interns who will assist with monitoring, planting at restoration sites, project outreach and project documentation. Preference will be given to college students. This experience will increase interns' prospects for obtaining environmental jobs in the future. The Town has an employee safety policy that will be applied to ensure safety during the project period.

Veteran engagement: The Brewster VFW Post 672 has been a part of the community since the 1930's. The Project Team will work with VFW Post 672 to include updates on the project in their on-line newsletter and to make periodic presentations on the project at their monthly dinners. Our goal is to engage veterans to become involved in monitoring, outreach, support or other appropriate activities.

D. Collaboration and Partnerships

The Town of Brewster has a long and successful record of working with partners to achieve common environmental goals. The Town has been working on different project components and complementary projects

now for a number of years. These projects and partners, stakeholders and in-kind support and level of review are summarized in the Other Documents Upload file.

E. Work Plan.

a. Project Team.

Mr. Chris Miller, Director, Department of Natural Resources and Conservation, Town of Brewster

Proposed role: Project Team Leader and staff support to the Brewster Coastal Committee.

Qualifications: Mr. Miller has a B.S. in Wildlife and Fisheries Biology from the University of Massachusetts, and an M.S. in Chemical Engineering from Wayne State University. Mr. Miller has a diverse background with 24 years of experience in environmental consulting, technical consulting, wildlife biology, and municipal service as a department head. He is a member of the Stony Brook Salt Marsh Restoration Project Team that was awarded one of 50 NOAA-ARRA coastal restoration grants in 2009. In 2011 he was given a Coastal America Partnership award in for the Stony Brook restoration project and NOAA's Excellence in Restoration Award. In 2013 the Brewster Conservation Trust selected the Brewster Department of Natural Resources as its Conservationists of the Year. Chris, his department staff and their volunteer group of 150 people will be closely involved in the proposed project.

Dr. Jo Ann Muramoto, Senior Scientist, Association to Preserve Cape Cod (APCC), and Massachusetts Bays Program Regional Coordinator for Cape Cod

Proposed role: partner in Project Team, overseeing APCC monitoring tasks, and member of the Brewster Coastal Committee.

Qualifications: Dr. Muramoto has 32 years of experience in coastal and wetlands science, regulation, management and policy. She has a B.S. in biology from Caltech and a Ph.D. in geological sciences from Cornell University. Her work experience includes a postdoctoral position at Woods Hole Oceanographic Institution, environmental and marine consulting, and conservation administrator for the Town of Falmouth. She is a member of the Stony Brook Salt Marsh Restoration Project Team that was awarded one of 50 NOAA-ARRA coastal restoration grants in 2009 and received a Coastal America Partnership award in 2011 for the Stony Brook restoration project. Jo Ann will assist the town with project management and outreach, and oversee APCC's monitoring task.

The Town of Brewster will hire a Project Manager responsible for oversight and coordination of the tasks outlined in this proposal. She/he will report to Mr. Miller, Natural Resources Director and will assist him in providing staff support to the Brewster Coastal Committee.

The Town of Brewster will select engineering firm(s) to prepare plans, permit applications and provide engineering services. The Town will seek a professional services contract to manage the development of the Brewster Coastal Resiliency Plan. The Town will execute separate agreements with PCCS to conduct Task 1.1 and with APCC to conduct salt marsh monitoring (Task 2.4); these services are exempt from the state procurement process, which will expedite selection and allow the Town to meet the schedules proposed in this grant application. The Town will bid construction tasks under Massachusetts General Law Chapter 30 Section 39 M (Public Works, non-building) construction.

b. Work Plan:

Brewster's proposed projects include assessment, planning, restoration, green stormwater infrastructure, monitoring and outreach. Tasks and subtasks have been described in detail above in Section B, the Project Narrative.

Task 1. Assessment, planning and design for coastal resiliency: This task involves assessment of the coastal resiliency of natural resources and development of a comprehensive Town-wide Coastal Resiliency Plan to reduce the vulnerability of coastal resources to sea level rise, coastal erosion, storm damage and flooding. . Subtasks are described below.

Subtask 1.1. Assessment of coastal sediment budget to identify resilient coastal habitat:

This subtask entails quantification of longshore sediment transport rates, sediment sources and sinks for the sub-regional littoral cell of the Cape Cod Bay coastline from the west end of Dennis to a small section of Orleans. using a simple geomorphic model developed by the Center for Coastal Studies (Giese, et al., 2011) Deliverables: field data, final modeling results, draft and final reports, two presentations to the Town of Brewster Coastal Committee, Town officials and consultant selected for the Coastal Resiliency Plan. Responsible parties: The Town will contract with the Provincetown Center for Coastal Studies to conduct the study. Schedule: This task will begin immediately upon approval of a contract with PCCS and will be concluded within a year. Completion of this task is needed for development of the Coastal Resiliency Plan (below). Milestones: Completion of field data collection; draft modeling results and report; final modeling results and report.

Subtask 1.2. Plan for restoration of natural systems: This subtask entails development of a plan to restore natural systems to increase their coastal resiliency. Deliverables: Draft and final restoration plan to improve coastal resiliency of natural ecosystems, GIS and other maps of natural systems and areas needing restoration, and recommendations for restoration and adaptation measures. Responsible party: The Town of Brewster and its contractor. Schedule: This subtask will be initiated upon selection of a contractor, and will be completed within two years. The Town hopes to award a contract for Subtasks 1.2 through 1.5 to a single contractor. Milestones: GIS and other maps and inventories of natural systems needing restoration, and draft and final restoration plans with recommendations.

Subtask 1.3. Planning and design for managed retreat of public access infrastructure from hazardous coastal areas: Work will involve development of plans and designs to relocate public access to Mants Landing Beach, the restored beaches at Linnell Beach and Crosby Beach, and other town beaches which have experienced storm damage. Deliverables: Public stakeholder meetings, survey, draft and final engineering plans and permitting. Responsible parties: The Town and its contractor. Schedule: This subtask will be initiated immediately upon selection of a contractor. Milestones: Public meetings, public support for proposed plans is expressed, survey, draft and final plans are prepared, permit applications prepared and submitted, permits obtained.

Subtask 1.4. Planning for the effects of rising sea level on water and wetlands: This task will evaluate the effects of sea level rise on Brewster's water resources and wetlands. Deliverables: Draft and final plan that inventories water resources at risk from rising sea level and recommendations for measures to improve habitat resiliency. Responsible parties: The Town and its contractor. Schedule: To be initiated upon selection of a contractor and completed within 2 years. Milestones: Draft and final plans.

Subtask 1.5. Coastal Resiliency Plan: This task involves synthesizing the results of assessment and planning Tasks 1.1 through 1.4 and developing a town-wide Coastal Resiliency Plan which will increase the coastal resiliency and habitat value of natural resources. Deliverables: Draft and final plans incorporating the results of Tasks 1.1-1.5, two public outreach meetings. Responsible parties: The Town and its consultant. Schedule: This subtask will be initiated upon selection of a contractor and completed within 2 years. Milestones: Draft and final plans, public outreach meetings; website postings

Task 2. Restoration and resiliency projects: These on-the-ground restoration and resiliency projects will be implemented concurrently with Task 1 because they have already been identified by the Town as priorities for increasing coastal resilience.

Subtask 2.1. Relocation of Breakwater Landing Beach parking area and restoration of beach and dune habitat. This task involves demolition and removal of the at-risk section of the paved town parking lot at Breakwater Landing Beach, reconstruction at a more inland area using porous pavement, restoration of the coastal beach and dune, installation of green stormwater infrastructure (e.g., vegetated bioretention or vegetated swale), and installing permeable vehicle and handicap access pathways. Deliverables: Draft and final plans, cost estimates, permitting, bid documents, construction, and oversight. Responsible parties: The Town and its contractors. Schedule: This subtask will be initiated upon selection of a contractor. Milestones: Draft and final plans, permit applications and received permits, bid specs, bids, construction milestones, oversight reports.

Subtask 2.2. Adaptive management of Mants Landing Beach parking area. Proposed activities include holding stakeholder meetings to build support for proposed flexible concrete mat as an interim replacement for the paved parking area, development of draft and final plans, permitting, bid specs, bids, construction and oversight. Monitoring will be provided in subtask 2.4, below. Deliverables: Stakeholder meetings, draft and final plans, cost estimates, permitting, bid documents, construction, and oversight. Responsible parties: The Town and its contractors. Schedule: To be completed within 2 years. Milestones: Draft and final plans, permit applications and received permits, bid specs, bids, construction milestones, oversight reports.

Subtask 2.3. Protecting salt marsh using an artificial oyster reef. Proposed activities include planning, permitting and installation of an artificial oyster reef along the seaward edge of an existing salt marsh east of Paines Creek Beach estuary. Oyster Castles will likely be utilized. Monitoring will be provided through Subtask 2.4, below.

Deliverables: Draft and final plans, permitting, and construction. Responsible parties: The Town and its contractor. Schedule: To be completed within 2 years. Milestones: Draft and final plans, permit applications, received permits, and construction.

Subtask 2.4. Monitoring of pre-restoration and post-restoration conditions at restored sites. The objective is to evaluate the progress and success of restoration at restored sites and to identify any issues that need to be addressed to improve restoration success. Deliverables: Monitoring data and reports describing pre- and post-restoration conditions. Responsible parties: As described above. Schedule: Pre-restoration monitoring will begin in 2014; post-restoration monitoring will be performed following completion of construction. Milestones: Draft and final pre-restoration and post-restoration reports.

Task 3. Green stormwater infrastructure: Proposed activities include design, draft and final plans, permitting, construction and oversight for the installation of vegetated stormwater swales. Deliverables: draft and final plans, permit applications, bid documents, construction, construction oversight, and evaluation of monitoring results. Responsible parties: the Town and its contractors. Schedule: To be completed within 2 years. Milestones: draft and final plans, permit applications submitted, permits received, bid documents, contractors selected, construction begins and ends, oversight, evaluation of monitoring results.

Task 4. Outreach and transferability: Throughout the entire project, the Town will exercise opportunities to provide outreach and provide user-friendly materials. Responsible parties: The Town. Schedule: Outreach will begin as soon as grant contract is approved. Milestones: Initial press release announcing grant, meetings, and development of deliverables.

c. Monitoring and Measuring Performance:

The primary performance measures for Brewster's coastal resiliency planning efforts will be the Board of Selectmen's adoption of Coastal Resiliency Plan, update of Multi-hazard Mitigation Plan and the Town administrator's integration of project priorities into the capital budget.

Technical monitoring will be performed by APCC and will include the following.

- For restored beach and dune habitat, measures of success include establishment of native beach and dune vegetation species following two growing seasons, documentation of wildlife utilizing restored habitat, re-establishment of natural sediment transport patterns as demonstrated by beach profiles, photographic documentation and comparison with the pre-restoration modeled sediment budget for the area.
- For the salt marsh/oyster reef project, measures of success include increased abundance and extent of salt marsh vegetation See Other Document Upload file for specific monitoring details

d. Return on Investment The greatest return on investment will be the reduction or elimination of storm-related damage to life, property and natural and cultural resources within the project area. Management strategies based on the findings from this study will increase the resiliency of ecosystem services of the Town's

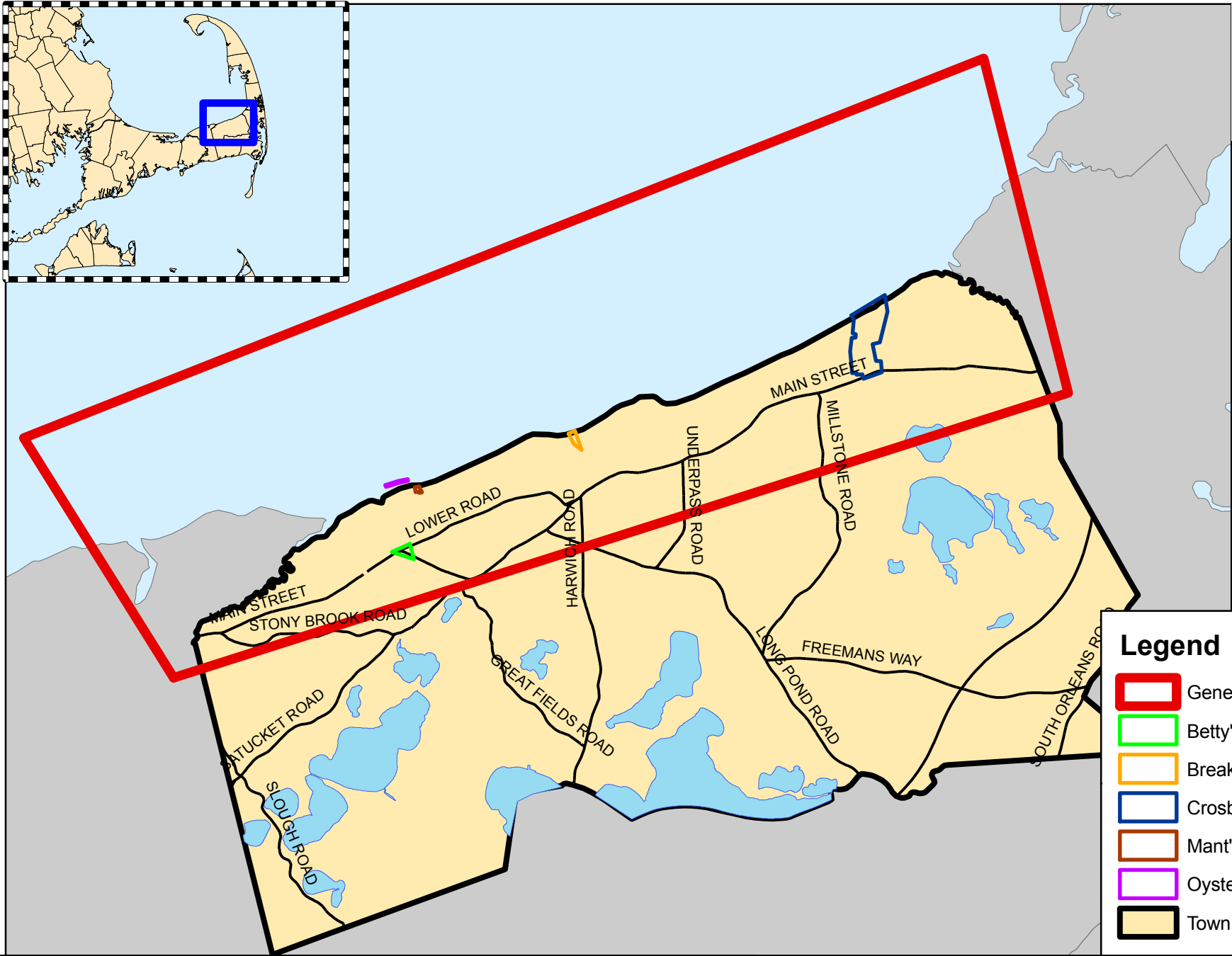
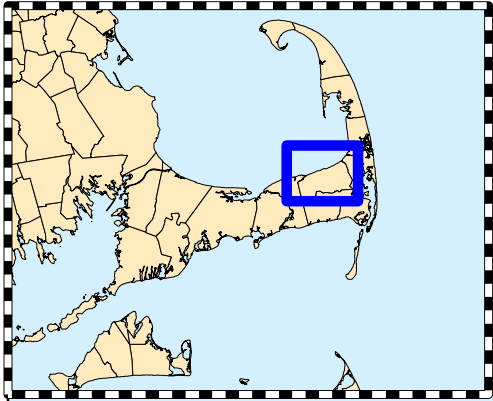
natural resources. These two points will also contribute to the continuation of tourism revenues into the local communities. In addition, there will be a reduced need for Town investments for repairs.

e. Risk:

The probability of substantial project failure is low. Brewster is enormously invested in its coastal resources and citizens are aware that if these resources are not well managed, the Town will experience environmental degradation and economic losses. Brewster has an excellent record of implementing environmental projects as demonstrated by its success in implementing many restoration and protection projects and as demonstrated by the 2011 Coastal America Partnership award for the Stony Brook restoration project. Brewster town government, citizens and businesses have a record of supporting environmental protection, as evidenced by numerous Town meeting votes supporting land acquisition for conservation and environmental projects. There are homes in Brewster located in high risk areas. The Town will work with such homeowners to come up with solutions that do not impair the coastal processes and resources that protect against storm damage and flooding.

f. Permits and Approvals: For restoration projects involving managed retreat of public access (Task 2), the Town anticipates that permits that will be required include an Order of Conditions under Massachusetts Wetlands Protection Act and Brewster Wetlands Bylaw, review by the Massachusetts Natural Heritage and Endangered Species Program and review by the Massachusetts Historical Commission. Other local approvals include permits from the Building Department for demolition of parking areas, construction and/or installation of adaptive parking areas. For the oyster reef-salt marsh pilot project, additional permits are anticipated (e.g., Massachusetts Division of Marine Fisheries).

g. Safety: All construction projects proposed will have a resident engineer and will go to bid to a contractor for construction. The selected contractor will develop a site-specific health and safety plan that will be evaluated by the project engineer. During heavy construction activity, site controls such as fencing will be employed to keep the general public away from site activities. Volunteer projects will all be overseen by a member of the Town of Brewster Department of Natural Resources or Department of Public Works. All work will be in accordance with Town safety procedures and policies.



Legend

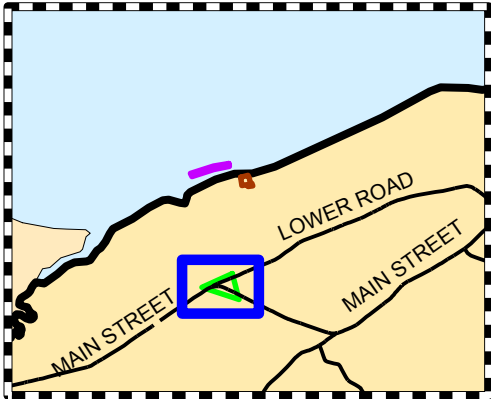
-  General Project Area
-  Betty's Curve
-  Breakwater Landing
-  Crosby Landing
-  Mant's Landing
-  Oyster Reef
-  Town of Brewster

**Brewster,
Massachusetts**

Building Coastal Resiliency
General Project Area

0 0.5 1 2
Miles
1 inch = 6,000 feet



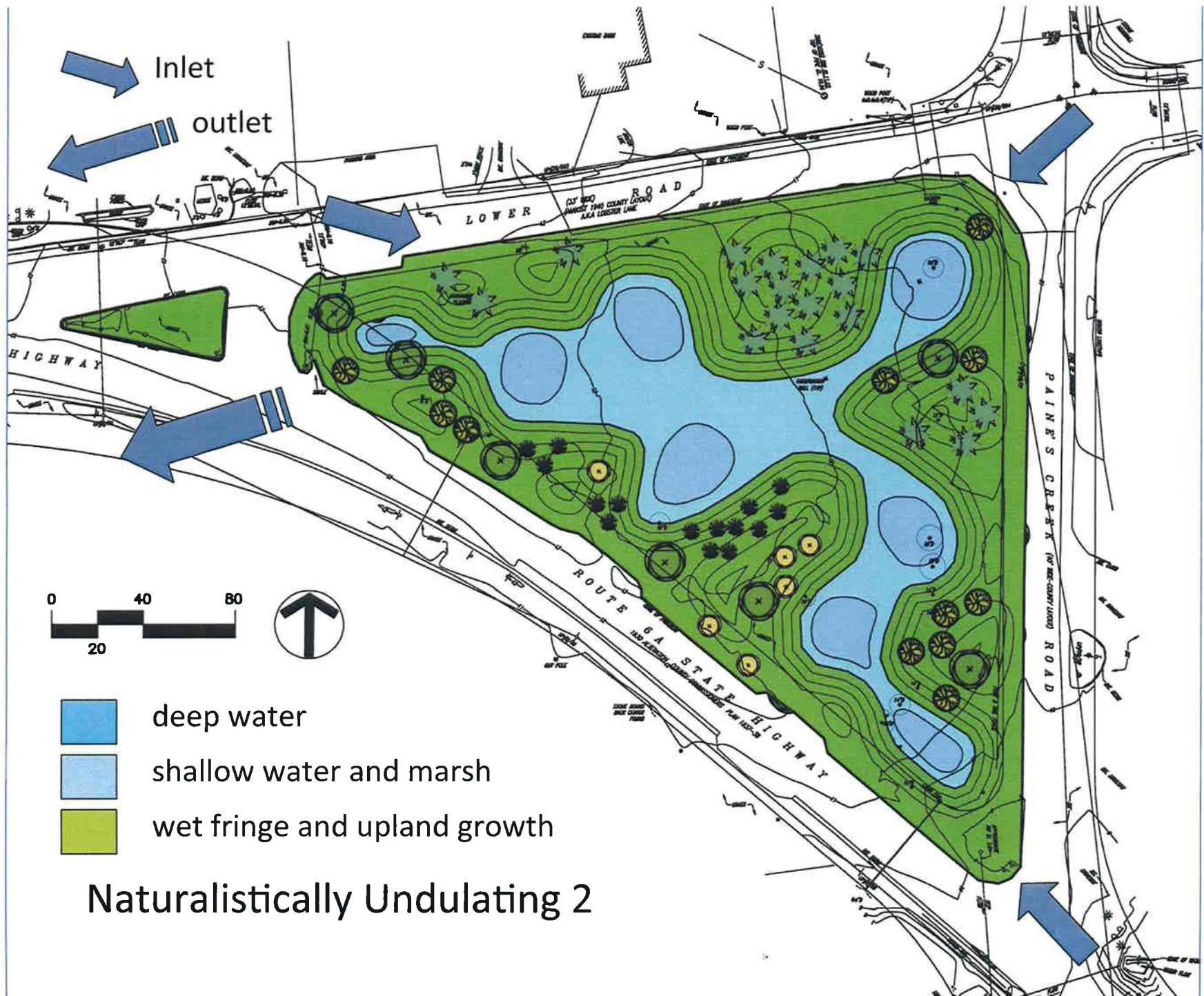


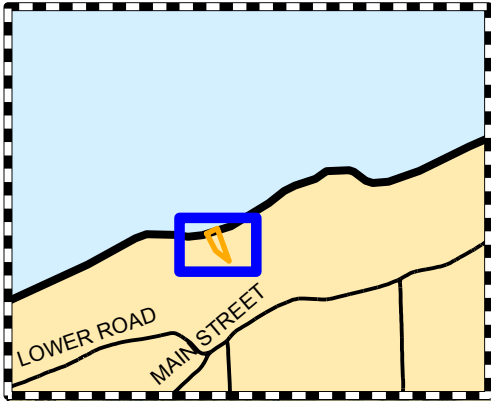
**Brewster,
Massachusetts**

**Building Coastal Resiliency
Betty's Curve**

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Feet
1 inch = 200 feet







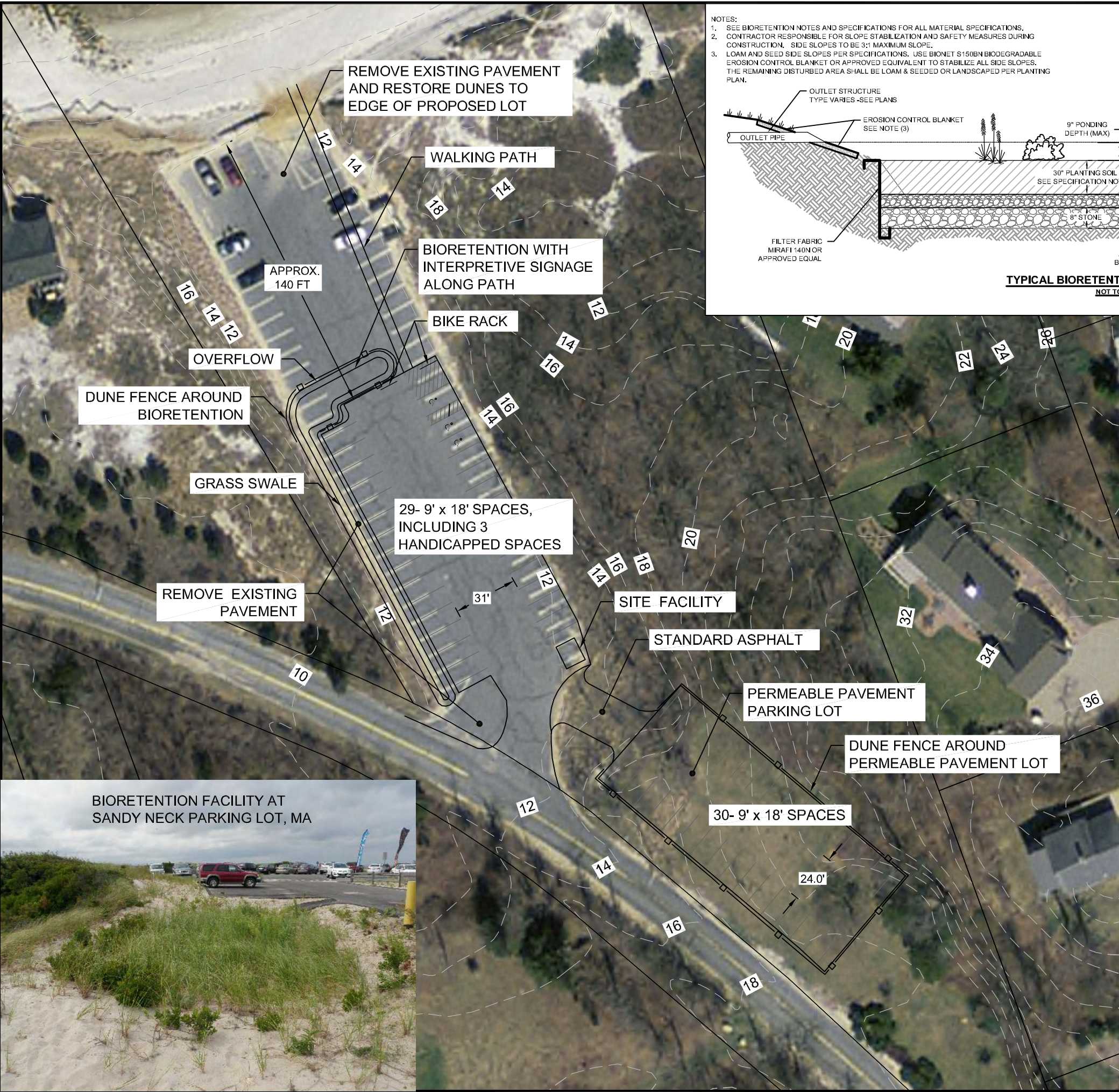
**Brewster,
Massachusetts**

**Building Coastal Resiliency
Breakwater Landing**

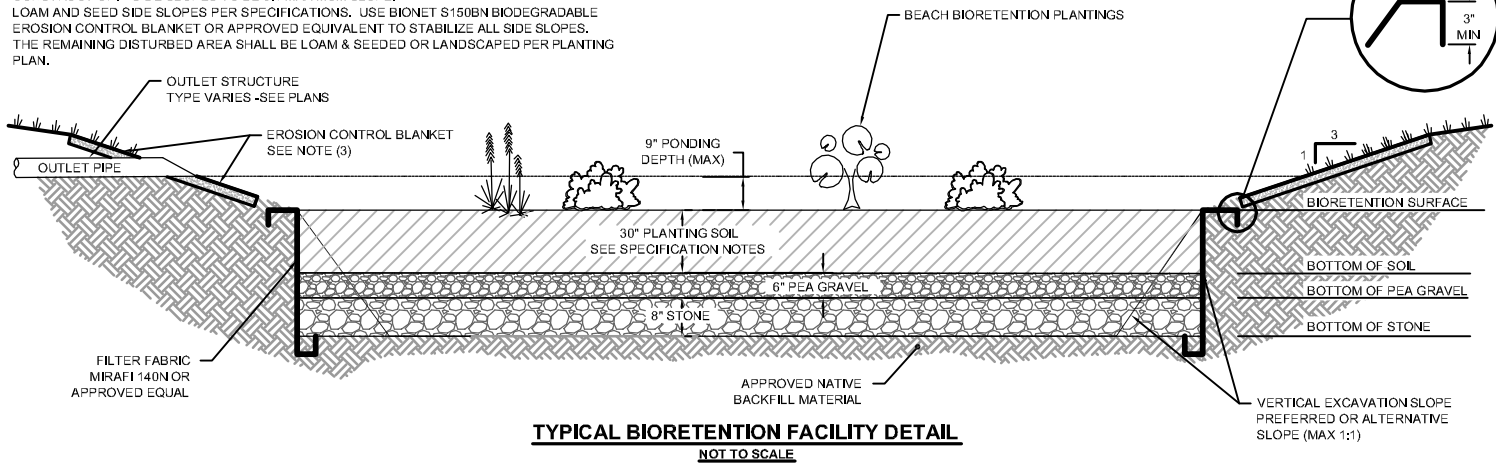
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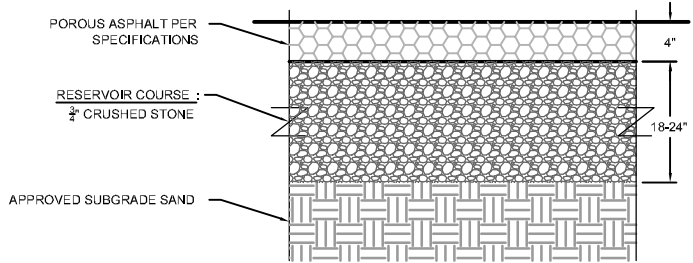
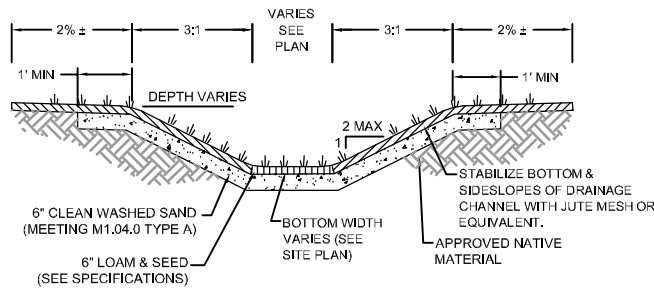
last modified: 01/17/14 printed: 01/17/14 by gc H:\Projects\2011\11109 Brewster Int. Wtr. Res. Mgt Plan\Drawings - 11109\140113_BREAKWATER CONCEPT_11109.dwg



- NOTES:
1. SEE BIORETENTION NOTES AND SPECIFICATIONS FOR ALL MATERIAL SPECIFICATIONS.
 2. CONTRACTOR RESPONSIBLE FOR SLOPE STABILIZATION AND SAFETY MEASURES DURING CONSTRUCTION. SIDE SLOPES TO BE 3:1 MAXIMUM SLOPE.
 3. LOAM AND SEED SIDE SLOPES PER SPECIFICATIONS. USE BIONET S150BN BIODEGRADABLE EROSION CONTROL BLANKET OR APPROVED EQUIVALENT TO STABILIZE ALL SIDE SLOPES. THE REMAINING DISTURBED AREA SHALL BE LOAM & SEEDED OR LANDSCAPED PER PLANTING PLAN.

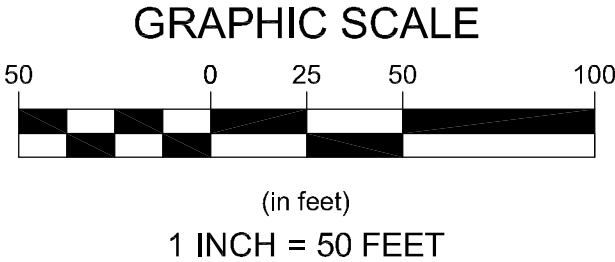


NOTE:
CONTRACTOR SHALL SHAPE CHANNEL IN A PARABOLIC MANNER.




- GENERAL NOTES:
1. SANDY LOAM AND/OR LOAMY SAND TOPSOIL MATERIAL SHALL BE EXCAVATED FROM ALL PAVED AREAS PRIOR TO SUB-BASE INSTALLATION.
 2. SUB-GRADE (EXISTING MATERIAL) SHALL CONSIST OF INERT MATERIAL THAT IS HARD, DURABLE STONE AND/OR COARSE SAND, FREE FROM LOAM AND CLAY TO A DEPTH NOT LESS THAN 4-FT BELOW THE FINISH PAVEMENT SURFACE.
 3. SUBGRADE FILL SHALL BE COMPACTED TO 95% COMPACTION UNLESS OTHERWISE DIRECTED BY THE ENGINEER.
 4. SEE SITE LAYOUT PLAN FOR PAVEMENT WIDTH AND LOCATION.
 5. SEE GRADING PLANS FOR PAVEMENT SLOPE AND CROSS SLOPE.

TYPICAL POROUS ASPHALT CROSS-SECTION
NOT TO SCALE



Revisions		Drawn By		Checked By		Design By		Date		By		Appr.		Revision	
		GSC		GSC		GSC		January, 2014							



Horsley Witten Group, Inc.
Sustainable Environmental Solutions
90 Route 6A
Sandwich, MA 02563
508-833-5600 voice
508-833-3150 fax

**BREAKWATER LANDING
BEACH RESTORATION
BREWSTER, MA**

CONCEPT

Plan Set

Plan Title

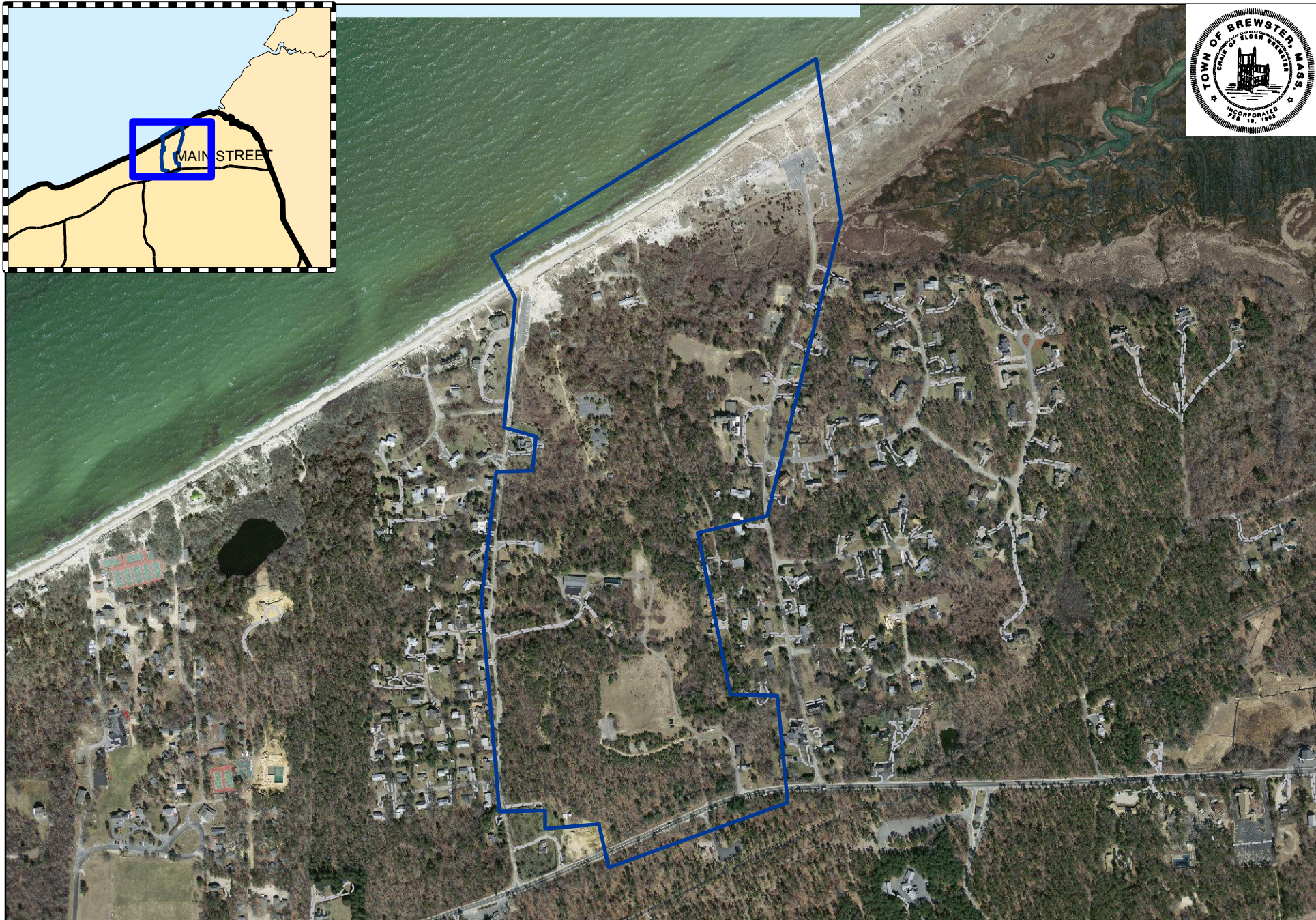
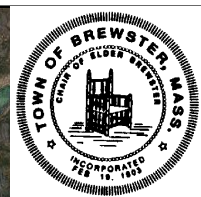
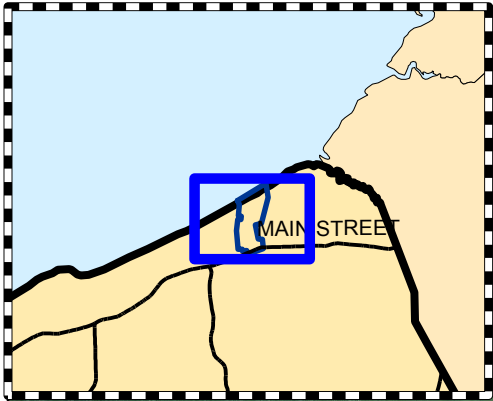
Prepared For:
Town of Brewster
2198 Main St. (Route 6A)
Brewster, MA 02631
Phone: (508) 896-3701

Survey & Preliminary Layout Provided By:
Horsley Witten Group
90 Route 6A
Sandwich, MA 02563
Phone: (508) 833-4600
Fax: (508) 833-3150

Registration:

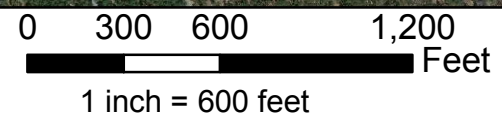
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Sheet Number:
1 of 1



**Brewster,
Massachusetts**

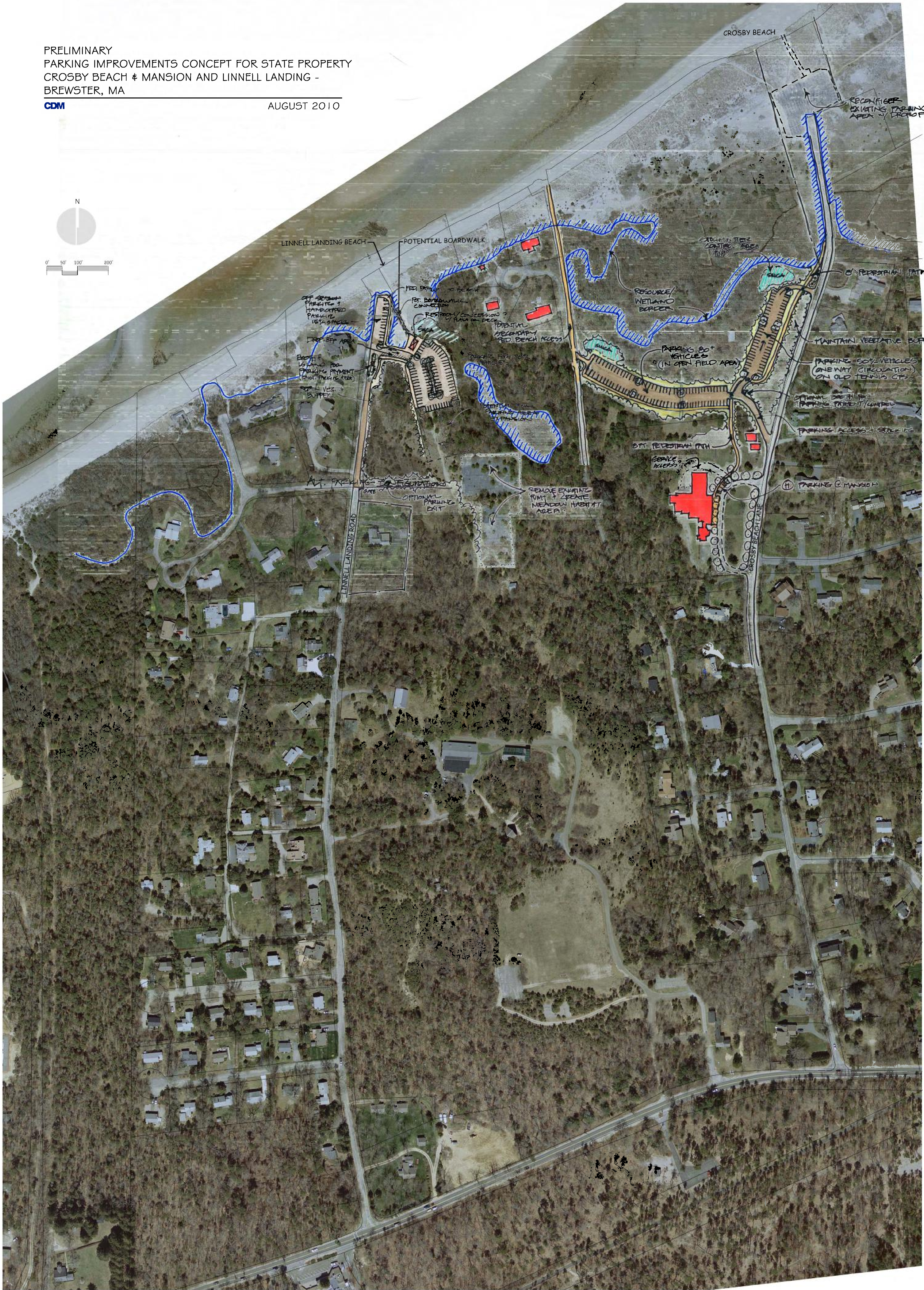
**Building Coastal Resiliency
Crosby Landing**

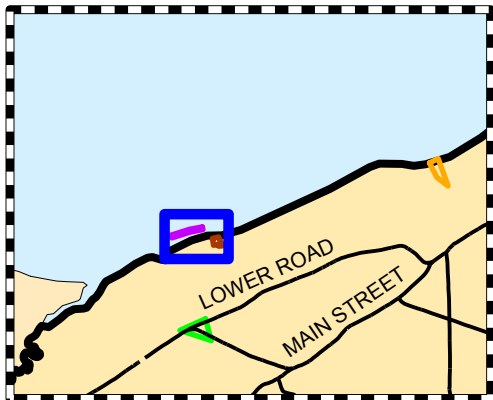
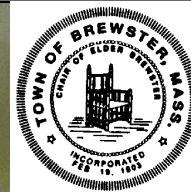


PRELIMINARY
PARKING IMPROVEMENTS CONCEPT FOR STATE PROPERTY
CROSBY BEACH & MANSION AND LINNELL LANDING -
BREWSTER, MA



CDM

AUGUST 2010



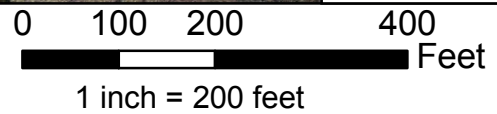


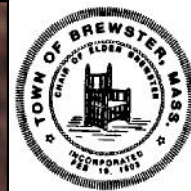
Legend

-  Mant's Landing
-  Oyster Reef

**Brewster,
Massachusetts**

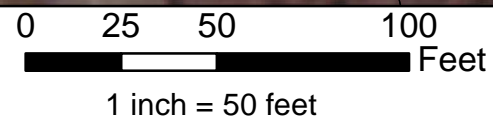
**Building Coastal Resiliency
Mant's Landing & Oyster Reef**





Town of Brewster
Conservation Department

Mant's Landing



N



Town of Brewster

2198 Main Street
Brewster, MA 02631-1898
Phone: (508) 896-3701
Fax: (508) 896-8089

Office of:

Board of Selectmen
Town Administrator

January 27, 2014

David O'Neill, Vice President, Conservation Programs
National Fish and Wildlife Foundation
1133 Fifteenth Street, NW Suite 1100
Washington, DC 20005

Re: Letter of support for the Town of Brewster's proposal *Building Coastal Resilience* to the National Fish and Wildlife Federation RFR for Hurricane Sandy Coastal Resiliency Competitive Grants Program

Dear Mr. O'Neill,

The Town of Brewster is pleased to submit its proposal- *Building Coastal Resilience*- to the National Fish and Wildlife Foundation to support the Town's efforts to plan for coastal change and to implement specific projects that increase the town's resiliency and restore the ecosystem functions of our coastal beaches, dunes and marshes. Brewster has nearly 6 miles of coast on Cape Cod Bay that takes the brunt of winter storms and hurricanes. The combination of being open to northeast and northwest winds and tidal ranges that can reach over 10 feet at high tide makes Brewster especially vulnerable to coastal storms and storm surge.

In the past five years we have been pro-active in retreating from one public beach parking lot that sustained repeated storm damage. In addition Brewster worked with a number of partners and secured federal funding for improving tidal flow in the Paines Creek/Stony Brook estuary that supports one of Massachusetts' significant herring runs. We have other public beach parking areas that have been storm-damaged and, because of their coastal location, are interfering with the natural functioning of the beach- dune- wetland complex at these locations.

Brewster's proposal lays out a more comprehensive approach to assessment, planning, design and implementation of a coastal resiliency program. We recognize the importance of integrating coastal science, technical information, public participation and sound design in a plan that will be the foundation for future Town actions. This work will be led by the Town's Department of Natural Resources and will involve the Conservation Commission, the Planning Department, the Department of Public Works and our Fire Department as the Town's Emergency Management Coordinator.

The Board of Selectmen are appointing a Coastal Committee made up of citizen volunteers that will work with the Brewster's Department of Natural Resources (DNR) in reviewing drafts of the plan and developing recommendations on short- and long-term actions. The DNR formed a volunteers group - FLATS: Friends of Lands, Aquatics, Trails and Shellfish- with over 100 members from the community; young and old, men and women, boy scouts and military veterans- who assist DNR on a

variety of coastal projects. Brewster will also work with its coastal neighbors, Dennis and Orleans, as the sediment that maintains our beaches is shared with both towns.

As the board responsible for setting town policies and priorities, the Board of Selectmen believes the work laid out in this proposal is critical to our future coastal management decisions. Brewster has demonstrated experience in managed retreat and coastal restoration. I urge you to support this important proposal that links ecosystem health with increased resiliency.


Sincerely,

Brewster Board of Selectmen



John Dickson, Chairman

James Foley, Vice-Chairman


Patricia Hughes, Clerk
Peter Norton
Benjamin deRuyter

WILLIAM R. KEATING
9TH DISTRICT, MASSACHUSETTS

COMMITTEE ON FOREIGN AFFAIRS
SUBCOMMITTEES
RANKING MEMBER
EUROPE, ELIASIA, AND EMERGING THREATS
ASIA AND THE PACIFIC

COMMITTEE ON HOMELAND SECURITY
SUBCOMMITTEES
COUNTERTERRORISM AND INTELLIGENCE
CYBERSECURITY, INFRASTRUCTURE
PROTECTION, AND
SECURITY TECHNOLOGIES



Congress of the United States
House of Representatives
Washington, DC 20515

WASHINGTON DC Office
315 CANNON HOUSE OFFICE BUILDING
WASHINGTON, DC 20515
(202) 225-3111

CAPE AND ISLANDS Office
297 NORTH STREET, SUITE 312
HYANNIS, MA 02601
(508) 771-0666

NEW BEDFORD Office
568 PLEASANT STREET, SUITE 309
NEW BEDFORD, MA 02740
(508) 999-6462

PLYMOUTH Office
2 COURT STREET
PLYMOUTH, MA 02360
(508) 746-9000

January 29, 2014

Mr. Martin Kodis
Re: Hurricane Sandy Coastal Resiliency Grant Program
Fish and Wildlife Service
U.S. Department of the Interior
1133 15th Street, NW, Suite 1100
Washington, D.C. 20005

Dear Mr. Kodis:

I am writing in support of the Town of Brewster's application for funding through the National Fish and Wildlife Federation (NFWF) and U.S. Fish and Wildlife Service's (USFWS) Hurricane Sandy Coastal Resiliency grant program.

Among the towns on Cape Cod, Brewster is a proven leader in protecting and restoring its natural coastal ecosystems. The Town restored 11 acres of salt marshes at Quivett Creek on the west end of town and then acres of salt marsh at Namskaket Marsh at the east end of town. In 2011, recognizing the integrated ecosystem services provided by coastal resources, Brewster and its partners received the President's Coastal America Partnership award for the \$1.6 million Stony Brook salt marsh and fish passage project which restored 41 acres of salt marsh at Paines Creek and Freeman's Pond and improved 3,000 feet of diadromous fish passage to 386 acres of herring spawning habitat in five headwater ponds.

Successful receipt of this funding would allow the Town to develop a coastal adaptation plan that encompasses its 8.3 mile long coast and adjacent upland areas to reduce the community's vulnerability to coastal storms, flooding, and erosion. In addition, the Town is proposing specific projects that involve coastal retreat, habitat restoration, and the use of green infrastructure to treat and manage stormwater at some of its coastal landings and parking areas. Brewster's comprehensive and long-term plan for coastal change will link ecosystem health with increased resiliency.

Brewster's efforts will provide a unique balance of community benefits and ecological benefits – including enhanced public beach access behind the coastal beach and dunes and protection from storm damage and flooding due to enhanced salt marshes and oyster reefs. The comprehensive coastal adaptation plan will allow for future retreat and migration of landforms and resources. Ecological benefits include restoration of beach and dune habitat for wildlife, protection of completed salt marsh and fish passage restoration projects at Stony Brook and Freeman's Pond by the accreting salt marsh and oyster reef and cleaner and, in some cases, no discharge of stormwater.

Brewster has demonstrated experience in managed retreat, and coastal restoration and this project will provide transferrable results that can be used by other nearby coastal communities. I thank you for your attention to this request and respectfully ask that you provide the Town's application with your full and fair consideration.

Sincerely,

A handwritten signature in blue ink, reading "Willi R. Keating". The signature is written in a cursive style with a large, stylized "W" and "K".

WILLIAM R. KEATING
Member of Congress



The Commonwealth of Massachusetts
MASSACHUSETTS SENATE

SENATOR DANIEL A. WOLF
Cape and Islands District

STATE HOUSE, ROOM 511C
BOSTON, MA 02133-1053

TEL. (617) 722-1570

FAX (617) 722-1271

DANIEL.WOLF@MASENATE.GOV
WWW.MASENATE.GOV

Chairman
LABOR AND WORKFORCE DEVELOPMENT

Vice Chairman
STATE ADMINISTRATION AND
REGULATORY OVERSIGHT

ENVIRONMENT, NATURAL
RESOURCES AND AGRICULTURE

COMMUNITY DEVELOPMENT
AND SMALL BUSINESS

PUBLIC SERVICE

TOURISM, ARTS AND
CULTURAL DEVELOPMENT
VETERANS AND FEDERAL AFFAIRS

January 24, 2014

David O'Neill, Vice President, Conservation Programs
National Fish and Wildlife Foundation
1133 Fifteenth Street, NW Suite 1100
Washington, DC 20005

Re: Letter of support for the proposal Brewster, Massachusetts - Building Coastal Resilience to the National Fish and Wildlife Foundation for Hurricane Sandy Coastal Resiliency Competitive Grants Program

Dear Mr. O'Neill,

As the state Senator representing the Cape Cod and Islands District, I am pleased to provide this letter expressing my strong support for Brewster's Building Coastal Resilience proposal. Brewster proposes to develop and implement a comprehensive coastal management plan that encompasses its 8.3 mile long coast and adjacent upland areas to reduce the community's vulnerability to coastal storms, flooding and erosion. All of Cape Cod is under threat from the impacts of climate change and the proactive approach proposed by Brewster may be a model for the other 14 Cape Cod towns. There are a number of important elements of the Brewster's proposed plan, including:

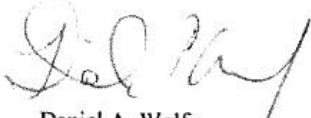
- Assessing coastal resiliency, including the development of a sediment budget that will provide detailed information on the source, volume and movement of sediment along the shore and identify where coastal erosion and accretion occur;
- Integrating GIS data and assessing the extent of current development in the A and V floodzones and delineating coastal resources including dunes, salt marshes and tidal creeks to assist in identifying high risk areas;
- Conducting a pilot study to evaluate the use of oyster reefs in promoting salt marsh accretion along Brewster's shoreline
- Planning and design to relocate at least two public beach parking areas that have been repetitively damaged to inland areas, followed by restoration of beach and dune habitat,
- Replacing aging stormwater infrastructure at coastal landings with green stormwater infrastructure to protect and improve water quality

In the last several years, winter storms and hurricanes (including Hurricane Sandy) have caused erosion and loss of at least 20 feet of the Town's shoreline. During the past three years Brewster has

been pro-active and, in 2012, re-located a public parking lot at a popular beach and restored beach and dune habitat. In 2011, recognizing the integrated ecosystem services provided by coastal resources, Brewster and its partners received the President's Coastal America Partnership award for the \$1.6 million Stony Brook salt marsh and fish passage project which restored 41 acres of salt marsh at Paines Creek and Freeman's Pond and improved 3,000 feet of diadromous fish passage to 386 acres of herring spawning habitat in five headwater ponds.

Brewster has demonstrated experience in managed retreat and coastal restoration. Funding from the Hurricane Sandy Resiliency Grants Program will support Brewster's more comprehensive and long-term planning for coastal change that links ecosystem health with increased resiliency.

Sincerely,



Daniel A. Wolf
Massachusetts State Senate
Cape and Islands District



THE GENERAL COURT OF MASSACHUSETTS
STATE HOUSE, BOSTON 02133-1053

January 24, 2014

David O'Neill, Vice President, Conservation Programs
National Fish and Wildlife Foundation
1133 Fifteenth Street, NW Suite 1100
Washington, DC 20005

Re: Hurricane Sandy Coastal Resiliency Competitive Grants Program, Brewster, MA

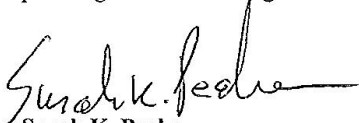
Dear Mr. O'Neill,

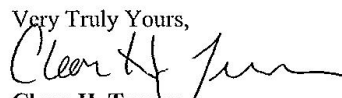
We are writing in strong support for Brewster's Building Coastal Resilience proposal. Brewster proposes to develop and implement a comprehensive coastal management plan that encompasses its 8.3 mile long coast and adjacent upland areas to reduce the community's vulnerability to coastal storms, flooding and erosion. All of Cape Cod is under threat from the impacts of climate change and the proactive approach proposed by Brewster may be a model for the other 14 Cape Cod towns. There are a number of important elements of the Brewster's proposed plan, including:

- Assessing coastal resiliency, including the development of a sediment budget that will provide detailed information on the source, volume and movement of sediment along the shore and identify where coastal erosion and accretion occur;
- Integrating GIS data and assessing the extent of current development in the A and V flood zones and delineating coastal resources including dunes, salt marshes and tidal creeks to assist in identifying high risk areas;
- Conducting a pilot study to evaluate the use of oyster reefs in promoting salt marsh accretion along Brewster's shoreline
- Planning and design to relocate at least two public beach parking areas that have been repetitively damaged to inland areas, followed by restoration of beach and dune habitat,
- Replacing aging stormwater infrastructure at coastal landings with green stormwater infrastructure to protect and improve water quality

In the last several years, winter storms and hurricanes (including Hurricane Sandy) have caused erosion and loss of at least 20 feet of the Town's shoreline. During the past three years Brewster has become proactive and, in 2012, re-located a public parking lot at a popular beach and restored beach and dune habitat. In 2011, recognizing the integrated ecosystem services provided by coastal resources, Brewster and its partners received the President's Coastal America Partnership award for the \$1.6 million Stony Brook salt marsh and fish passage project which restored 41 acres of salt marsh at Paines Creek and Freeman's Pond and improved 3,000 feet of diadromous fish passage to 386 acres of herring spawning habitat in five headwater ponds.

Brewster has demonstrated experience in managed retreat and coastal restoration. Funding from the Hurricane Sandy Resiliency Grants Program will support Brewster's more comprehensive and long-term planning for coastal change that links ecosystem health with increased resiliency.


Sarah K. Peake
State Representative
4th Barnstable

Very Truly Yours,

Cleon H. Turner
State Representative
1st Barnstable



Town Of Brewster
2198 Main Street
Brewster, Massachusetts 02631-1898
(508) 896-3701
FAX (508) 896-8089

**Comprehensive Water
Planning Committee**

January 27, 2014

David O'Neill, Vice President, Conservation Programs
National Fish and Wildlife Foundation
1133 Fifteenth Street, NW Suite 1100
Washington, DC 20005

Re: Letter of support for the Town of Brewster's proposal *Building Coastal Resilience* to the National Fish and Wildlife Federation RFR for Hurricane Sandy Coastal Resiliency Competitive Grants Program

Dear Mr. O'Neill,

The Town of Brewster Comprehensive Water Planning Committee (CWPC) is pleased to support Brewster's proposal- *Building Coastal Resilience*- to the National Fish and Wildlife Foundation to support the Town's efforts to plan for coastal change and to implement specific projects that increase the town's resiliency and restore the ecosystem functions of our coastal beaches, dunes and marshes.

Brewster started its Integrated Water Planning efforts in 2008 with hiring our first Town Planner, whose responsibilities included overseeing the development of the Town's Integrated Water Resources Management Plan (IWRMP). The CWPC was formed in 2009. Over the last 5 years, the Town has produced an analysis of the existing information and materials available for the IWRMP; several projects to address areas where data was lacking, or where data sources could not be linked under present conditions; a needs analysis for drinking water, wastewater, surface water and stormwater; and a report analyzing possible alternatives to address both existing regulatory limits on nutrients and surface water pollution issues. To date, the Town has appropriated over \$700,000 for water planning efforts.

The planning portion of this proposal will provide critical data needed to complete Brewster's IWRMP, including the effects of sea level rise on our sole source aquifer, and changes to stormwater loading in coastal areas. It will also provide essential planning tools to manage the long term effects of an eroding and receding shoreline on Brewster's citizens and infrastructure. The implementation portion of the grant application will address significant stormwater issues identified in the IWRMP by minimizing its generation, and by using natural systems to absorb and treat nutrients and pollutants. It will also improve the resilience of the Town's infrastructure in these vulnerable areas.

As the Chair of the board responsible for evaluating Brewster's water resources, I believe the work laid out in this proposal is critical to our future Town planning decisions. The CWPC has voted to support this grant application. I urge you to support this important proposal that links ecosystem health with increased resiliency.

Sincerely,

Lem Skidmore, MS, MPH, Chair
Brewster Comprehensive Water Planning Committee



Town of Brewster
2198 MAIN STREET
BREWSTER, MASSACHUSETTS 02631-1898

Office of: CONSERVATION COMMISSION

January 24, 2014

David O'Neill, Vice President, Conservation Programs
National Fish and Wildlife Foundation
1133 Fifteenth Street, NW Suite 1100
Washington, DC 20005

Re: Letter of support for the proposal *Brewster, Massachusetts - Building Coastal Resilience* to the National Fish and Wildlife Foundation for Hurricane Sandy Coastal Resiliency Competitive Grants Program

Dear Mr. O'Neill,

As Chairman of the Town of Brewster Conservation Commission, I encourage the National Fish and Wildlife Foundation to fund the Town's proposal *Building Coastal Resilience*. Brewster proposes to develop and implement a comprehensive coastal management/adaptation plan that encompasses its dynamic 6 mile long coast and adjacent upland areas to reduce the community's vulnerability to coastal storms, flooding and erosion. In addition, the Town is proposing essential projects that involve coastal retreat, habitat restoration, and the use of green infrastructure to treat and manage stormwater at some of its coastal landings and parking areas. Brewster's comprehensive and long-term plan for coastal change will link ecosystem health with increased resiliency.

Among towns on Cape Cod, Brewster is a proven leader whose citizens have consistently supported protecting and restoring its natural coastal ecosystems. In the 1960s, the citizens voted to acquire nearly all of the coastal salt marsh properties in town, including the two large estuaries at each end of the coastline, Namskaket and Quivett. Over the last decade, the Town restored 11 acres of salt marsh at Quivett Creek on the west end of town, 10 acres of salt marsh at Namskaket Marsh at the east end, 21 acres of salt marsh surrounding Freemans Pond, the town's only salt pond, and a further 20 acres of salt marsh at Paines Creek in the Stony Brook valley. In addition, Brewster and its partners, including the Brewster Conservation Trust and the Massachusetts Department of Conservation and Recreation, have preserved more than one-third of its land area as open space for conservation and water resource protection which will provide drinking water and passive and active recreational opportunities for the general public well into the foreseeable future.

Moreover, Brewster's project will provide significant ecological benefits, including the restoration of beach and coastal dune habitat for wildlife, storm damage prevention and flood control, as well as providing a continuing sediment source for coastal beaches, and the protection of completed salt marsh and fish passage restoration projects at Stony Brook and Freeman's Pond by the accreting salt marsh and oyster reef. The Stony Brook Herring Run and surrounding ecosystem which encompasses all of Stony Brook Valley, 3 major kettle ponds, and a large marsh system. The entire Stony Brook ecosystem encompasses 900 acres and supports a variety of wildlife, finfish and freshwater shellfish and amphibians as well as a variety of wildlife including endangered plants and species. It is one of the Commonwealth's most prolific herring runs. Projects will also treat and in some cases eliminate direct discharges of stormwater into protected resource areas affecting these critical natural resources.

Brewster has proven its ability to conduct innovative and progressive projects with proactive programs, such as the coastal retreat at Paines Creek Beach, which included removal of a paved parking lot from a dune with restoration to its original natural condition.

The comprehensive coastal management plan will allow for future retreat and migration of landforms and resources. This project will provide direct impacts with transferrable results to our coastal resources that can be recognized and implemented by other coastal communities, on and off Cape Cod. Brewster has demonstrated success in managed retreat and coastal restoration. Your support of this essential proposal will benefit our community and allow us to continue to accomplish our environmental protection goals for our fragile coastline.

Respectfully yours,



Paul C. Wightman, Chairman
Brewster Conservation Commission



Brewster Fire Department

1657 Main Street
Brewster, MA 02631
Phone 508-896-7018 Fax 508-896-4245



January 24, 2014

David O'Neill, Vice President, Conservation Programs
National Fish and Wildlife Foundation
1133 Fifteenth Street, NW Suite 1100
Washington, DC 20005

Re: Letter of support for the proposal *Brewster, Massachusetts - Building Coastal Resilience* to the National Fish and Wildlife Foundation for Hurricane Sandy Coastal Resiliency Competitive Grants Program

Dear Mr. O'Neill,

As the Town of Brewster Fire Chief, I encourage the National Fish and Wildlife Foundation to fund the Town's Building Coastal Resilience proposal. Brewster proposes to develop and implement a comprehensive coastal adaptation plan that encompasses its 6 mile long coast and adjacent upland areas in a proactive manner designed to reduce the community's vulnerability to coastal storms, flooding and erosion. In addition, the Town is proposing specific projects that involve coastal retreat, habitat restoration and the use of green infrastructure to treat and manage storm water at some of its coastal landings and parking areas.

I have cooperatively worked with our town GIS staff to develop estimates of properties and infrastructure that will be affected by rising sea levels and potential future storm events and coastal flooding. Based on this work we have found the need to develop and establish long term plans to replace vulnerable coastal infrastructure and to identify and provide access points to these areas for emergency vehicles and personnel as some of the most critical components of our community's emergency response plan. The proposed development of a coastal resilience strategy will be a key part of how Brewster adapts and keeps its citizens safe. These planning efforts will also be essential for our citizens to plan for evacuation, if needed, and to understand the risks inherent in living in a low lying coastal environment. Most importantly, the plan will ensure our community's first responders are provided an effective work environment that supports their personal safety and the safety of our residents.

I believe this project will also provide transferrable results that can be used by other coastal communities, on and off Cape Cod. Based on past performance the Town of Brewster has demonstrated experience in managed retreat and coastal restoration. I urge you to support this important proposal.

Sincerely,


Robert Moran, Chief
Brewster Fire & Rescue Department

BREWSTER POLICE DEPARTMENT

Chief Richard J. Koch, Jr.

631 Harwich Road

Brewster, Massachusetts 02631

Phone 508-896-7011 www.brewsterpolice.org Fax 508-896-4513

January 24, 2014

David O'Neill, Vice President, Conservation Programs
National Fish and Wildlife Foundation
1133 Fifteenth Street, NW Suite 1100
Washington, DC 20005

RE: Letter of support for the proposal *Brewster, Massachusetts - Building Coastal Resilience* to the National Fish and Wildlife Foundation for Hurricane Sandy Coastal Resiliency Competitive Grants Program

Dear Mr. O'Neill,

As the Town of Brewster's Chief of Police, I encourage the National Fish and Wildlife Foundation to fund Brewster's proposal *Building Coastal Resilience*. Brewster proposes to develop and implement a comprehensive coastal adaptation plan that encompasses its 6 mile long coast and adjacent upland areas to reduce the community's vulnerability to coastal storms, flooding and erosion. In addition, the Town is proposing specific projects that involve coastal retreat, habitat restoration and the use of green infrastructure to treat and manage stormwater at some of its coastal landings and parking areas.

My years of experience in responding to Brewster's coastal storm events and the changes to our coast due to rising sea levels and significant coastal erosion raise increasing concerns with public safety based on these effects. In recent years we have had storm events undermine and damage homes, damage roads and parking areas at the beaches, and flood typical evacuation routes.

Brewster needs to develop and establish long term plans to replace or change vulnerable coastal infrastructure and provide for access by emergency vehicles and personnel during and after these events. The proposed planning efforts will be a key part of how Brewster keeps its citizens and first responders safe. These planning efforts will also be essential for our citizens to plan for evacuation, if needed, and to understand and adapt to the risks inherent in living in a low lying coastal environment.

This project will also provide transferrable results that can be used by other coastal communities. Brewster has demonstrated experience and success in managed retreat and coastal restoration. I urge you to support this important proposal.

Sincerely,



Chief Richard J. Koch, Jr.
Town of Brewster Police Department

"In Partnership With Our Community"

3225 MAIN STREET • P.O. BOX 226
BARNSTABLE, MASSACHUSETTS 02630



CAPE COD
COMMISSION

(508) 362-3828 • Fax (508) 362-3136 • www.capecodcommission.org

January 28, 2014

David O'Neill, Vice President, Conservation Programs
National Fish and Wildlife Foundation
1133 Fifteenth Street, NW Suite 1100
Washington, DC 20005

Re: Letter of support for the proposal Brewster, Massachusetts - Building Coastal Resilience to the National Fish and Wildlife Foundation for Hurricane Sandy Coastal Resiliency Competitive Grants Program

Dear Mr. O'Neill,

I am writing to encourage the National Fish and Wildlife Foundation to fund the Town's proposal Building Coastal Resilience. Brewster proposes to develop and implement a comprehensive coastal resiliency plan that encompasses its 6- mile long coast and adjacent upland areas to reduce the community's vulnerability to coastal storms, flooding and erosion. In addition, the Town is proposing some specific projects that involve coastal retreat, habitat restoration and the use of green infrastructure to treat and manage stormwater at some of its coastal landings and parking areas. Brewster's comprehensive and long-term plan for coastal change will link ecosystem health with increased resiliency.

Among towns on Cape Cod, Brewster is a proven leader in protecting and restoring its natural coastal ecosystems. The Town restored over 40 acres of salt marsh in the Paines Creek/Stony Brook watershed on the west end of town and 10 acres of salt marsh at Namskaket Marsh at the east end. Brewster is developing a state-recognized Integrated Water Resource Plan that sensibly integrates management of drinking water supplies, stormwater, and wastewater into one plan. Finally, the town and its partners have preserved more than one-third of its land area as open space for conservation and water resource protection.

Brewster's project will provide a unique balance of community benefits and ecological benefits. Community benefits will include public beach access behind the coastal beach and dunes and protection from storm damage and flooding due to enhanced salt marshes and oyster reefs. The comprehensive coastal resiliency plan will allow for future retreat and



migration of landforms and resources. Ecological benefits include restoration of beach and dune habitat for wildlife, protection of completed salt marsh and fish passage restoration projects at Stony Brook and Freeman's Pond by the accreting salt marsh and oyster reef and cleaner and, in some cases, no discharge of stormwater.

The Cape Cod Commission is also seeking NFWF funding to conduct a regional Coastal Resiliency Assessment to develop appropriate adaptation responses for vulnerable coastal resource areas. The work proposed by the Town of Brewster and the Cape Cod Commission are complementary. We anticipate the regional assessment will identify additional future projects for implementation in the Town of Brewster.

Sincerely,



Patty Daley
Deputy Director
Cape Cod Commission



January 27, 2014

Mr. David O'Neill
Vice President, Conservation Programs
National Fish and Wildlife Foundation
1133 Fifteenth Street, NW Suite 1100
Washington, DC 20005

**Re: Letter of support for Town of Brewster, Massachusetts proposal
"Building Coastal Resilience"
National Fish and Wildlife Foundation for Hurricane Sandy Coastal Resiliency
Competitive Grants Program**

Dear Mr. O'Neill,

On behalf of the Association to Preserve Cape Cod (APCC), I am pleased to provide this letter expressing our strong support for the proposal by the Town of Brewster to conduct coastal resiliency planning and restoration projects to benefit fish and wildlife habitat. This letter also describes our commitment to providing match for the proposed project.

APCC was founded in 1968 to promote policies and programs that enhance the protection of the natural resources of Cape Cod. APCC is the Cape's largest environmental organization and has 5,000 members from all 15 towns on Cape Cod. In our 46 years, we have successfully advocated for protection of the Cape's water resources, open space, and natural resources, and the adoption of regional growth management policies (see www.apcc.org).

Since 2006 APCC has served as the Regional Service Provider of the Cape Cod region of the Massachusetts Bays Program, whose mission is to protect and restore the coastal ecosystems of Cape Cod Bay and Massachusetts Bay (<http://www.mass.gov/eea/agencies/mass-bays-program/>). APCC's Senior Scientist, Dr. Jo Ann Muramoto, is the Mass Bays Program's Regional Coordinator for Cape Cod and provides technical assistance, outreach and facilitation to help communities restore and protect coastal ecosystems of Cape Cod Bay. This letter also describes the Mass Bays Program commitment to providing match for the proposed project.

The Town of Brewster has long been a leader in environmental protection and restoration on Cape Cod, and was recognized by APCC in 2012 for environmental excellence. Their achievements include utilizing a comprehensive watershed approach to restoring the Stony Brook watershed, which included restoration of 41 acres of salt marsh, restoration of fish passage to 386 acres of herring spawning habitat, stormwater treatment, and preservation of

hundreds of acres of open space in the Stony Brook watershed. The Town also restored two other tidally-restricted salt marshes at Quivett Creek and Namskaket Marsh, preserved one-third of the town's area as open space for conservation and habitat, enacted the first Natural Resource Protection District zoning bylaw on Cape Cod to protect water resources, and nominated the Inner Cape Cod Bay Area of Critical Environmental Concern.

The Town of Brewster is also a leader in coastal adaptation. In 2012, it became the first town on Cape Cod to conduct a managed retreat from the coast by removing a municipal parking area that suffered from repetitive storm damage and relocating it to an inland location, followed by restoration of beach and dune habitat. This project was successfully completed and now serves as the model for the Town's proposed tasks for managed retreat at other town beaches.

APCC and the Mass Bays Program Cape Cod region are proud to partner with the Town of Brewster on this important proposal to conduct managed retreat and restoration of beach and dune habitat, prepare a comprehensive Coastal Resiliency Plan that will restore and protect coastal habitat in order to increase resiliency, install an oyster reef as a living shoreline to enhance salt marsh growth, and install green stormwater infrastructure to protect water quality at restored sites. We will provide match for the Town's proposal as described below:

- \$11,000 of in-kind assistance with project management, outreach and coordination: APCC and the Mass Bays Program Regional Coordinator for Cape Cod will provide in-kind match of 200 hours (100 hours per year for two years), amounting to \$11,000;
- \$5,000 of in-kind match to conduct photographic monitoring of coastal erosion and the restoration of beaches and dunes, to be provided by APCC through a grant from the Eddy Foundation of Brewster;
- \$5,000 of in-kind match to monitor the Freeman's Pond salt marsh that was restored in 2013. This marsh is immediately inland of the barrier beach at Paines Creek Beach and the salt marsh where the oyster reef is proposed. This match will be provided by APCC through a grant from the Eddy Foundation of Brewster.

- **Total in-kind match to be provided: \$21,000.**

In addition, we will coordinate with the Town to provide the results of our ongoing project evaluating the effects of sea level rise on the mid-Cape's groundwater system as soon as feasible. APCC has been working with the U.S. Geological Survey which is modeling the effects of sea level rise on groundwater, and with the Cape Cod Commission (see <http://www.apcc.org/sealevelrise/index.html>). We anticipate that preliminary results will be available beginning in Summer 2015 and final results in Summer 2016. These results will be useful for the Town's proposed task to evaluate the effects of sea level rise on Brewster's water and wetlands habitat.

The Town of Brewster has a proven record in achieving on-the-ground restoration of coastal habitat and implementing coastal adaptation projects that improve coastal resiliency of fish

and wildlife habitat. We strongly urge you to support this important proposal.

Sincerely,

A handwritten signature in blue ink, appearing to read 'Ed DeWitt', with a stylized flourish extending to the right.

Ed DeWitt
Executive Director

cc: Charles Sumner, Town Manager, Town of Brewster
Chris Miller, Director, Department of Natural Resources, Town of Brewster
Pamela DiBona, Executive Director, Massachusetts Bays Program



Wellfleet Bay Wildlife Sanctuary
PO Box 236, South Wellfleet, MA 02663
508-349-2615 (phone), 508-349-2632 (fax)
wellfleet@massaudubon.org

January 27, 2014

Mr. David O'Neill
Vice President, Conservation Programs
National Fish and Wildlife Foundation
1133 Fifteenth Street, NW Suite 1100
Washington, DC 20005

Re: Letter of support for Town of Brewster, Massachusetts proposal
"Building Coastal Resilience"
National Fish and Wildlife Foundation for Hurricane Sandy Coastal Resiliency Competitive
Grants Program

Dear Mr. O'Neill,

On behalf of Mass Audubon, I am pleased to provide this letter expressing our strong support for the proposal by the Town of Brewster to conduct coastal resiliency planning and restoration projects to benefit fish and wildlife habitat, particularly oyster restoration.

Mass Audubon works to protect the nature of Massachusetts for people and wildlife. Together with more than 100,000 members, we care for 33,000 acres of conservation land, provide educational programs for 200,000 children and adults annually, and advocate for sound environmental policies at local, state, and federal levels. For more than 100 years, Mass Audubon has been a leader in biological conservation—through the preservation of critical habitats that are essential to the well being of plants, wildlife, and people. Our sanctuary system helps protect 154 of Massachusetts' 430 endangered species, and 20 of the approximately 30 endangered or threatened habitats.

Mass Audubon's Wellfleet Bay Wildlife Sanctuary (WBWS) is located on the outer arm of Cape Cod, encompasses 1,100 acres and contains a valuable mix of habitats. The sanctuary's staff works with many local and statewide partners to preserve the Cape's unique environment and to promote conservation action at the local, state and federal levels. The sanctuary undertook the creation of the state's first experimental oyster reef restoration from 2009-2012, testing three materials for settlement and growth of wild oysters and their ability to increase biodiversity and create essential fish habitat. In our capacity as advisors to the project, lessons learned from this novel research will be applied to the oyster restoration components of the Brewster proposal.

The Town of Brewster has long been a leader in environmental protection and restoration on Cape Cod. Their achievements include the Stony Brook salt marsh restoration project restored 41 acres of tidally-restricted salt marsh, restoration of fish passage to 386 acres of herring spawning habitat, stormwater treatment, restoration of the the Quivett Creek and Namskaket tidally-restricted salt marshes, preservation of one-third of the Town's area as open space for conservation and habitat, and designation of the Inner Cape Cod Bay Area of Critical Environmental Concern. Brewster was also one of the first towns on Cape Cod to conduct a managed retreat from the coast by removing a town parking area that suffered from repetitive storm damage and restoring beach and dune habitat. This successful project is the model for the Town's proposed tasks for managed retreat at other town beaches.

The Town also conducted an initial test to determine whether oyster reefs could be created along the Brewster shoreline, both as a living shoreline and to enhance biodiversity. This initial test showed that wild set of oyster spat is possible in Brewster, and plans are underway to partner with a local hatchery to augment the local set with tank sets using wild stock.

We are pleased to partner with the Town of Brewster on this important proposal that includes construction of an oyster reef as a living shoreline to protect and enhance growth of a salt marsh, managed retreat, restoration of beach and dune habitat, comprehensive planning to restore and protect coastal habitat to increase resiliency, and green stormwater infrastructure to protect water quality.

Thank you. We strongly urge you to support this important proposal which will benefit coastal habitat of fish and wildlife by increasing their resiliency to coastal erosion, flooding and sea level rise.

Sincerely,



Bob Prescott
Executive Director

cc: Charles Sumner, Town Manager, Town of Brewster
Chris Miller, Director, Department of Natural Resources, Town of Brewster

Conceptual Plans: Table of Contents

1. Adaptive Management of Mants Landing Parking Area
2. Pilot Oyster Reef to Protect Expanding Salt Marsh Habitat

Adaptive management of Mants Landing Beach parking area.

Mants Landing is a town-owned approximately 11 acre beach and dune area with a paved 42-space parking area and approximately 1,500-foot public beach located on Cape Cod Bay. This is also an important access point to the Brewster Flats for vehicles providing emergency response, and for the public who utilize it for over sand transport of machinery and sand for nourishment projects on private properties within about a 1 mile radius. It also provides essential access to three private oyster aquaculture grants plus the Town's aquaculture propagation area. This is also one of the public boat mooring areas on the bay, and providing access and parking is essential for boaters. In addition, this is the access point for the proposed oyster reef pilot project.

The paved parking area at Mants Landing Beach suffers from repetitive storm damage (see attached photographs). Protective vegetative dunes at the north side of the parking lot have been repeatedly destroyed, and the parking lot is regularly inundated on storm events greater than the 10-year storm. This inundation has caused extensive damage to the pavement, requiring expensive and short lived repairs.

The objective is to remove fill material and asphalt pavement from within a dune, with replacement by a resilient material that would also minimize the generation of stormwater. This project would test the use of a removable permeable flexible articulating concrete mat (ACM) as an interim replacement for a paved parking area on a beach until a permanent solution can be found. The design would also allow a measured retreat by allowing segments of the mat to be removed as erosion affects the area fronting the beach. It would also minimize the ongoing environmental affects a failing asphalt and fill parking area have on the surrounding habitat.

If the mat is successful (as measured by public acceptance, reduced need for repairing the parking area after each storm and improved beach and dune habitat as demonstrated by monitoring, it will be utilized at other vulnerable Town beach parking areas until more permanent solutions are identified. Such flexible concrete mats have been utilized elsewhere on Cape Cod with success as boat ramps and to improve small parking areas.

The existing pavement and underlying fill would be excavated and removed. Clean sand fill compatible with the surround dune deposits would be brought in and the lot and entrance at the road would be regraded to minimize the effect of inundation and flooding to the roadway to the south. The ACMs would be underlain by a geogrid, filter fabric, and a layer of stone. At the end of the lot near the beach, the ACMs would be embedded into the beach for added resilience.

A short seasonal boardwalk would be placed directly adjacent to the entrance to the beach for foot traffic and to provide handicap access to the beach area.

Permits required would include a Notice of Intent with the Brewster Conservation Commission and state.

Initial estimates of costs are derived from a parking lot removal and restoration project completed at the Town of Brewster beach located approximately ½ mile west, Paines Creek Beach. At that location, a similar threatened paved parking lot on a coastal dune was removed and the area was restored to dune, with beach grass plantings and some native shrubs.

The area of pavement at Mants Landing is approximately 20,000 square feet. All pavement and underlying fill would be excavated and removed to expose native materials. The grade in the parking area would then be adjusted, with a lower grade near the beach at the north, and raised grade to the south. This would be more in keeping with the surrounding properties, and would lessen storm damage to roads and houses further inland (see photographs following; winter storms often inundate the parking area and flow to the south down the paved roadway).

The cost to remove the pavement and replace with screened compatible grain size sand for the Paines Creek parking area were \$40,000. This parking area is approximately 2.5 times the size, bringing the estimate to remove asphalt and fill and replace with compatible sand at \$100,000. Given the five years between the Paines project projected start times, with a 3% increase in project cost per year, the estimate should be \$112,550.

The area previously paved, including a section of the access road into the lot and a short access out to the beach, would be replaced with ACM (ArmorFlex or equivalent). Each section of ACM is approximately 8x16 foot, or 128 square feet. We estimate 156 sections of mat would be required. Based on pricing at Cotchpicut in Chatham, MA (a FEMA funded project), an installed price with underlying stone, geogrid and fabric, is \$1,781 per section. That brings the ACM installation to \$277,836.

Total construction costs are thus \$390,386.

Design and Permitting is typically estimated at 10 to 12% of construction cost. The engineer estimates a design budget of \$40,000. Design and Permitting includes:

- Final design
- Reviews with the Town (1 or 2 workshops) and coordination with key staff and Department Heads
- Presentation to BOS
- Wetland permitting
- Development of bid ready documents (plans and specs)
- Administration support with the funding agency

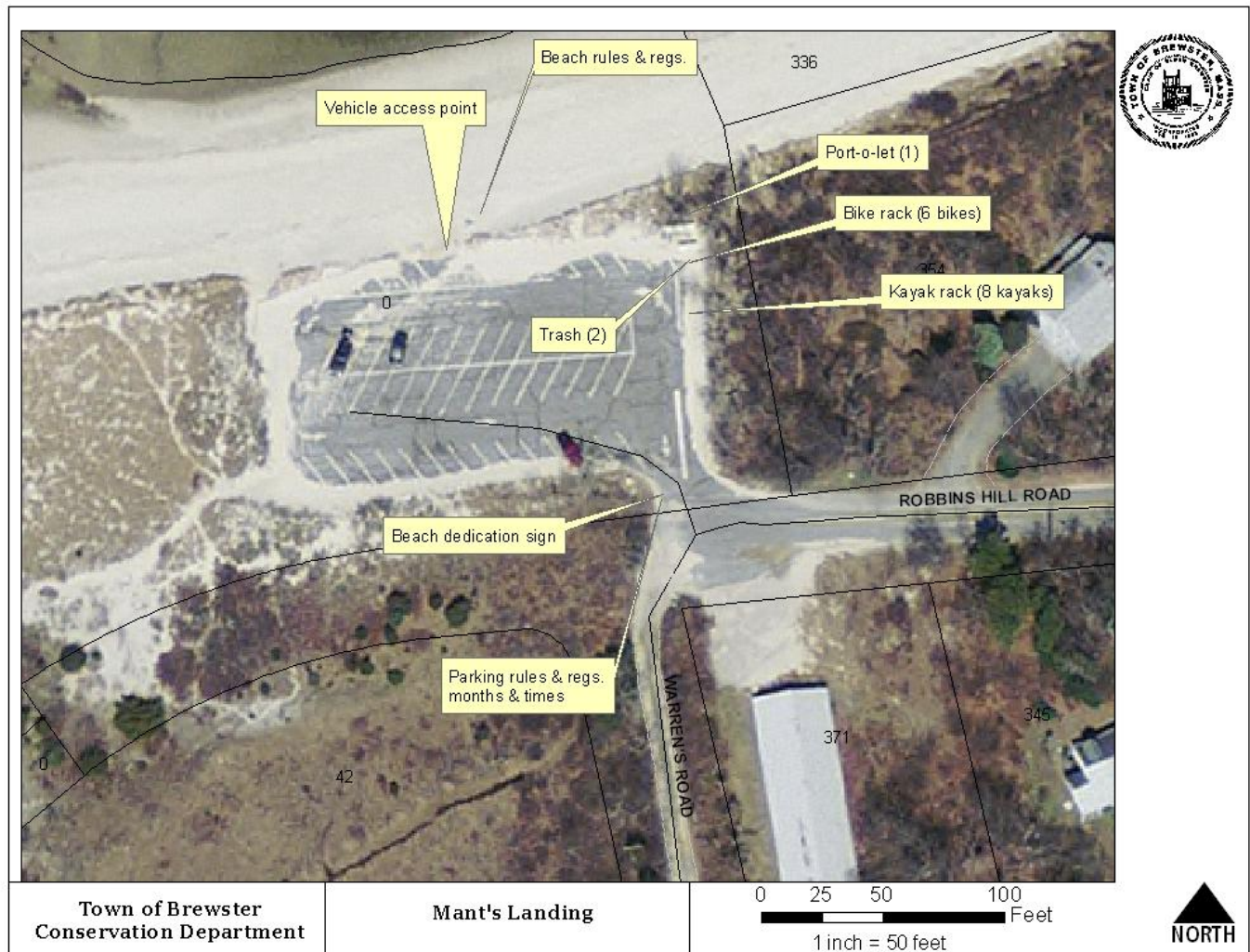
Engineering services during construction is typically estimated at 12 to 15% of construction, or a budget of \$45,000. These services include:

- Advertisement in Central Register, bidding, and evaluation of the apparent low bidder
- Shop drawing review
- Review and administration of payment applications by the General Contractor
- General construction management
- Onsite inspection at key points in construction
- Administration support with the funding agency
- Development of record drawings
- Development of an Operations and Maintenance Plan
- Development of beach profiles and recommendations on nourishment
- Project closeout

Budget summary, Mants Landing, Brewster:

\$40,000	Engineering design, permitting, bidding
\$45,000	Engineering review and monitoring of project, project closeout
\$112,550	Removal of asphalt and fill, replacing with screened sand compatible with adjoining dunes, grading
<u>\$277,836</u>	Installation of ACMs, including compacted stone and geogrid/fabric
\$475,386	Subtotal
\$ 47,537	10% construction contingency
\$522,923	Project estimate

Mant's Landing



Location: End of Robbins Hill Road, Map 2, Lot 1

Parking: 44 spaces including two handicap spaces. Permit required June 15 to Labor Day, 9am to 3pm.

Amenities: One port-o-let and two trash containers, bike rack, kayak rack. Memorial Day to Labor Day (inclusive). Access point for aquaculture, emergency access for boats and vehicles.

Erosion: -1.97 to -2.1 feet per year lost.

Features: Popular beach in summer; adjoins Paines Creek to the west. Anchorage located on flats to west of parking lot. Town shellfish grant plus three private grants on flats due north of parking area.

Parking lot is situated at the end of Robbins Hill Road at a low point adjacent to the beach. The parking area is protected by a minimal dune supported in part by split rail fencing at the parking lot's northern edge with some buried boulders. Further west is a dune area fronted by a sandy beach and remnant salt marsh.

Storm Damage:

Protective dunes at north edge of parking lot are gone, along with regulatory sign, split rail fencing, beach grass and other plantings. North edge of pavement broken, undermined and lifted; will need to be removed and repaving of north end of lot.



Photo during storm, taken from Robbins Hill Road, outside of landing looking northwest. Note waves within parking area and water running down street to south.



View looking east at entrance to beach, winter 2013. Dune, beach sign and fencing is gone, asphalt lifted or missing.



View looking west from entrance to beach, winter 2013. Dune and fencing is gone, asphalt lifted and broken.



Looking northwest, showing extent of damage pavement, sand in parking area, missing dunes and fencing.



Facing west at the northern border of the Mants Landing parking area, winter 2012. Dunes were rebuilt later in spring.



Facing east at the northern border of the Mants Landing parking area, winter 2012. Dune rebuilt and replanted with beach grass later that spring.

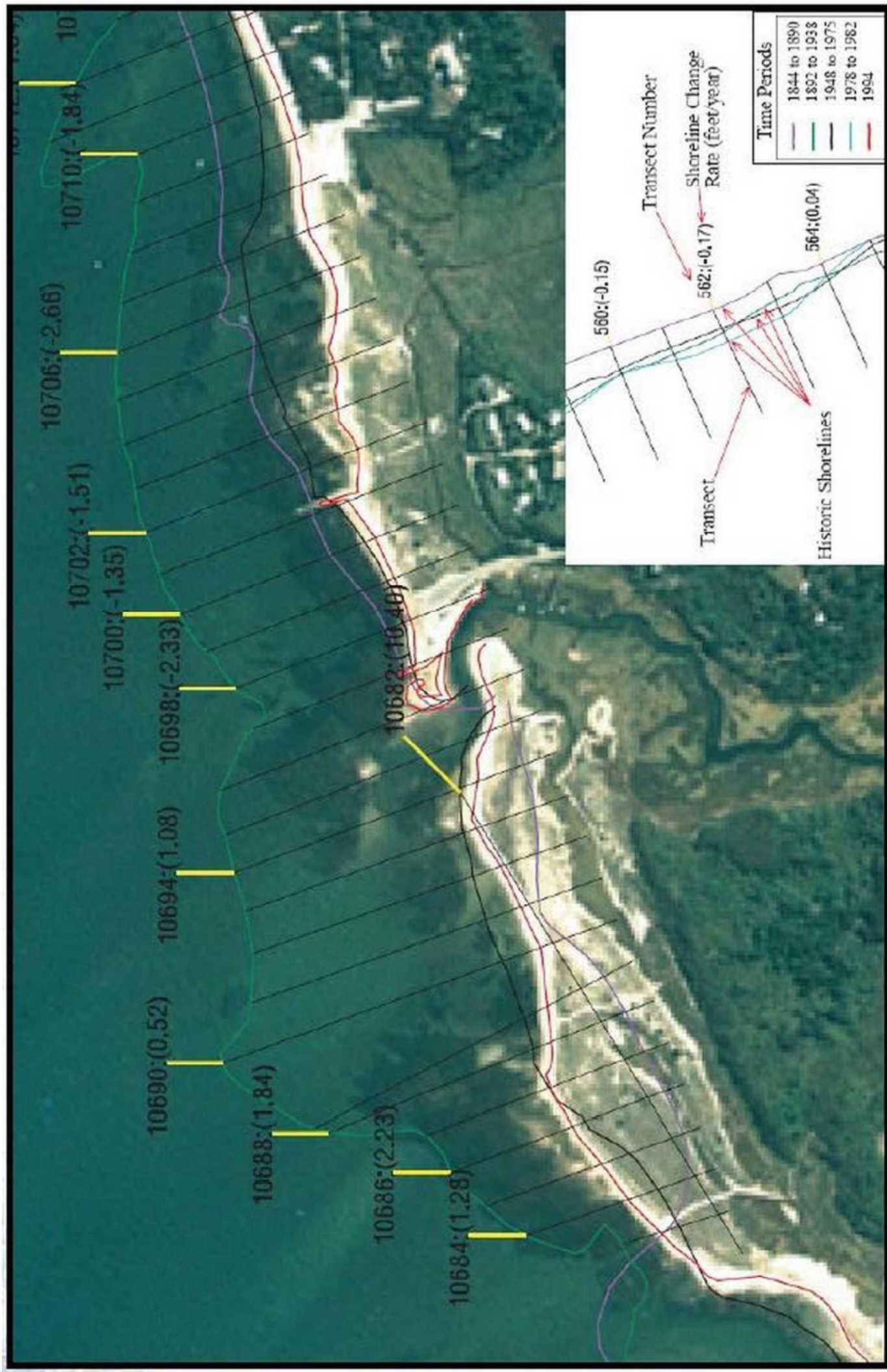


Figure 17. Rates of historic shoreline change between 1847 and 1994 as determined by Thieler et al. (2001).



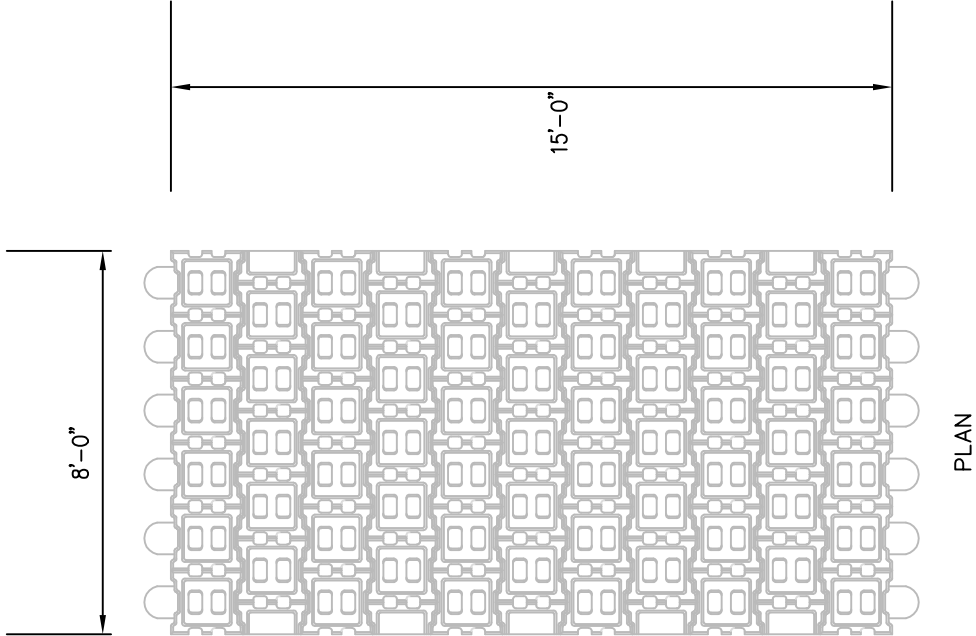
Figure 18. Aerial showing NHESP priority habitat for state-protected rare species (Mass GIS).

1. SUPPLY ALL MATERIAL, EQUIPMENT AND LABOR FOR CONSTRUCTION OF CABLE CONCRETE MATS ALONG THE SHOREFRONT AS DESCRIBED AND SHOWN ON PLAN AND DETAILS.

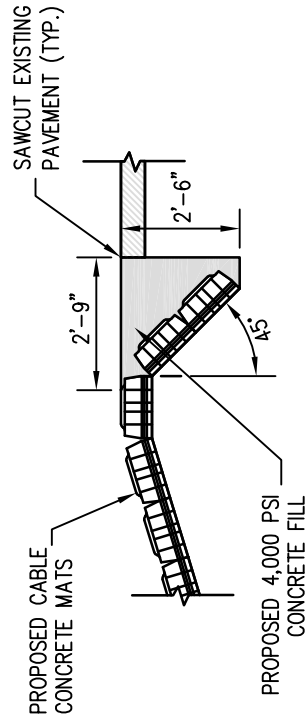
2. ACCESS FOR MATERIAL AND EQUIPMENT TO BE FROM THE SUBJECT PROPERTY. CONTRACTOR IS RESPONSIBLE FOR OBTAINING ALL PERMISSION REQUIRED FOR USE OF ANY AND ALL ACCESS.
3. PERFORMANCE OF THE WORK SHALL BE IN COMPLIANCE WITH THE PLAN AND DETAILS, AND ORDER OF CONDITIONS ISSUED BY THE CHATHAM CONSERVATION COMMISSION FOR THE REFERENCED PROJECT AND AS DESCRIBED BELOW.
4. ANY FUTURE MAINTENANCE REQUIRED ON THE CONCRETE MATS SHALL NOT COMMENCE UNTIL THE CHATHAM CONSERVATION AGENT HAS FIRST BEEN NOTIFIED AS TO THE SCOPE OF THE REPAIRS.
5. ANY FILL MATERIAL REQUIRED SHALL BE CLEAN COMPACTED COARSE SAND BROUGHT ONTO SITE BY CONTRACTOR.
6. FILTER CLOTH SHALL BE OF MIRAFI 600X, OR EQUAL, AS APPROVED BY THE ENGINEER.
7. THE FILTER CLOTH SHALL BE PLACED IN TWO LAYERS ON TOP OF THE GRADED SLOPE OF THE BANK, AND BENEATH THE TOE MATERIAL. THE JOINTS OF THE FILTER CLOTH SHALL BE STAGGERED AT LEAST SIX FEET APART. THE FILTER CLOTH SHALL BE OVERLAPPED AT LEAST THREE FEET IN EACH DIRECTION. ENDS OF FILTER CLOTH SHALL NOT BUTT EACH OTHER.
8. UPON COMPLETION OF THE PROJECT, THE CONTRACTOR SHALL RESTORE THE AREA AND ACCESS TO MATCH THE PRE-CONSTRUCTION CONDITIONS.
9. CONCRETE MATS SHALL BE CONTACT OR AS APPROVED BY ENGINEER. CONTRACTOR SHALL INSTALL MATS IN ACCORDANCE WITH MANUFACTURERS SPECIFICATIONS.
10. THE PROJECT SHALL BE INSPECTED BY THE ENGINEER APPROXIMATELY 28 DAYS (ONE MOON TIDE) AFTER CONSTRUCTION TO ENSURE PROPER STABILIZATION.



*2 LAYERS OF BX1100 OR BX1200, AT SUBGRADE AND MIDDLE OF DRAINAGE ROCK



NOT TO SCALE



NOT TO SCALE

UNIT THICKNESS "A"
CLASS 50 6.00"

Protecting salt marsh using a constructed oyster reef

Summary: The Town of Brewster Department of Natural Resources has identified a salt marsh located to the east of Paines Creek Beach and Paines Creek estuary in Brewster as an ideal location to test the development of a living shoreline using a constructed oyster reef. The goal of this pilot project is to install an oyster reef as a living shoreline along the seaward margin of this salt marsh to test whether the oyster reef will enhance salt marsh growth and/or protect it from erosion and storm damage. Another goal is to enhance biodiversity by providing a hard complex substrate for aquatic organisms that will attract fish and wildlife.

Unlike Freeman's Pond salt marsh and Stony Brook salt marsh which were recently restored (2013 and 2010, respectively), this salt marsh is located facing the open waters of Cape Cod Bay. It represents the most seaward of the salt marshes located within the Paines Creek-Stony Brook-Freeman's Pond estuary system that comprises a single estuary system. As the most seaward salt marsh, it is exposed to the brunt of storm waves and tides. At the same time it protects the barrier beach at Paines Creek Beach, as well as the newly restored Freeman's Pond salt marsh immediately inland of the barrier beach, and the Stony Brook salt marsh located in the upper estuary. This task will test the use of a constructed oyster reef to protect the seaward margin of this salt marsh and to enhance salt marsh growth and expansion.

This project builds upon a successful oyster reef restoration project that was undertaken by one of our partners, the Wellfleet Audubon Sanctuary, which has successfully built and maintained an oyster reef for the purpose of enhancing biodiversity. The Wellfleet oyster reef was built and monitored with a grant from the Mass Bays Program whose goal as a National Estuary Program is to promote the protection and restoration of the coastal ecosystems of Cape Cod Bay and Massachusetts Bay (see Oyster reef monitoring project, Wellfleet Audubon Sanctuary, Mass Bays Program Research & Planning Grant, 2011, posted at: <http://www.mass.gov/eea/agencies/mass-bays-program/grants/mbp-r-and-p-grants-fy12.html>).

The Town will be contracting Dr. Mark Faherty of the Wellfleet Audubon Sanctuary, the principal investigator for Wellfleet Sanctuary's oyster reef project, to guide and advise the Town with project design, permitting, construction and monitoring. Dr. Faherty agrees that the oyster substrate that is most likely to succeed is a commercially-available substrate known as "Oyster Castles" (see <http://www.alliedconcrete.com/materials/oyster-castles/>). The Town will also test the use of oyster shell cultch obtained from local sources and remote set oyster bags (the latter are available from the nearby Aquacultural Research Corporation, Inc. located in the Town of Dennis several miles away, which is a major East Coast supplier of oyster sets).

This project also builds upon an initial pilot project undertaken by the Town and Barnstable County Shellfish Department at another location, Breakwater Landing. Activities included an initial photo survey of the proposed oyster reef area, driving stakes to provide reference points for evaluating sand migration, preliminary survey transects, beach profiles, placement of sea clam shell (cultch) and oyster remote set, assessment of sand migration and suitability for natural oyster set. This initial test in 2009-2010 using Oyster Castles, showed that there is substantial oyster spat in the area due to aquaculture activities nearby. In addition, the Oyster Castles did not get buried by drifting sand. The proposed location for this pilot project to protect and enhance salt marsh is similar in nature to the initial pilot project location, Breakwater Landing.

Expected outcomes of this oyster reef project are:

- Establishment of a natural, living breakwater consisting of an oyster reef (*Crassostrea virginica*) that will create habitat for additional oyster growth and reef formation, as measured by photographic documentation of oyster growth and reef formation;
- Development of complex habitat for juvenile and adult fish, invertebrates and wildlife, including birds, as measured by monitoring of nekton, fish utilization and avian visitation;
- Reduction of wave energy that will protect the salt marsh landward of the oyster reef, as evidenced by comparison of erosion against a control site where no oyster reef will be installed;
- Enhancement of growth and/or area covered by salt marsh vegetation, as measured by monitoring of the perimeter of the salt marsh, abundance of salt marsh species, height and vigor of salt marsh species, ocean salinity (see Task 2.5, below);
- Improvement of water quality through filtration by oysters, as measured by water quality monitoring of total dissolved solids and turbidity.
- Increased coastal resiliency and protection of the newly-restored Freeman's Pond salt marsh and Stony Brook salt marsh, e.g., protection of the investment in restoration of these resources.

Proposed activities for Paines Creek Beach oyster reef:

a) Survey of oyster reef site and salt marsh. Proposed activities include an initial georeferenced photographic survey of the proposed oyster reef area and salt marsh as well as an elevational survey to establish topography and locations of reference points (stakes). The perimeter of the salt marsh will be mapped using differential GPS and will be flagged for monitoring reference points. Beach profiles will be surveyed to evaluate pre- and post-oyster-reef effects on sediment. Additional survey points will be collected at reference areas updrift and downdrift in order to determine the potential impacts of the shellfish habitat on coastal processes. Methods for the beach surveys will follow procedures outlined in USACE Engineering Manual 1110-2-1003. The Town will contract a surveyor to conduct the elevational survey of the reef and salt marsh area, the edge of the salt marsh and other reference points. APCC will flag the edge of the salt marsh and install reference stakes. Town staff and interns and APCC will conduct photomonitoring of the site.

b) Design of oyster reef. Proposed activities include evaluation of the site, design of the oyster reef, and development of conceptual plans. As described above, the Town expects to use Oyster Castles which have proved resistant to storm damage and successful for promoting oyster reef formation. The Town will contract this work to Dr. Mark Faherty of the Wellfleet Audubon Sanctuary who will serve as advisor for this task and for permitting, construction and monitoring.

c) Permitting. Permits will be required from the Massachusetts Division of Marine Fisheries, Conservation Commission and Board of Selectmen. The Town will contract this work to a consultant.

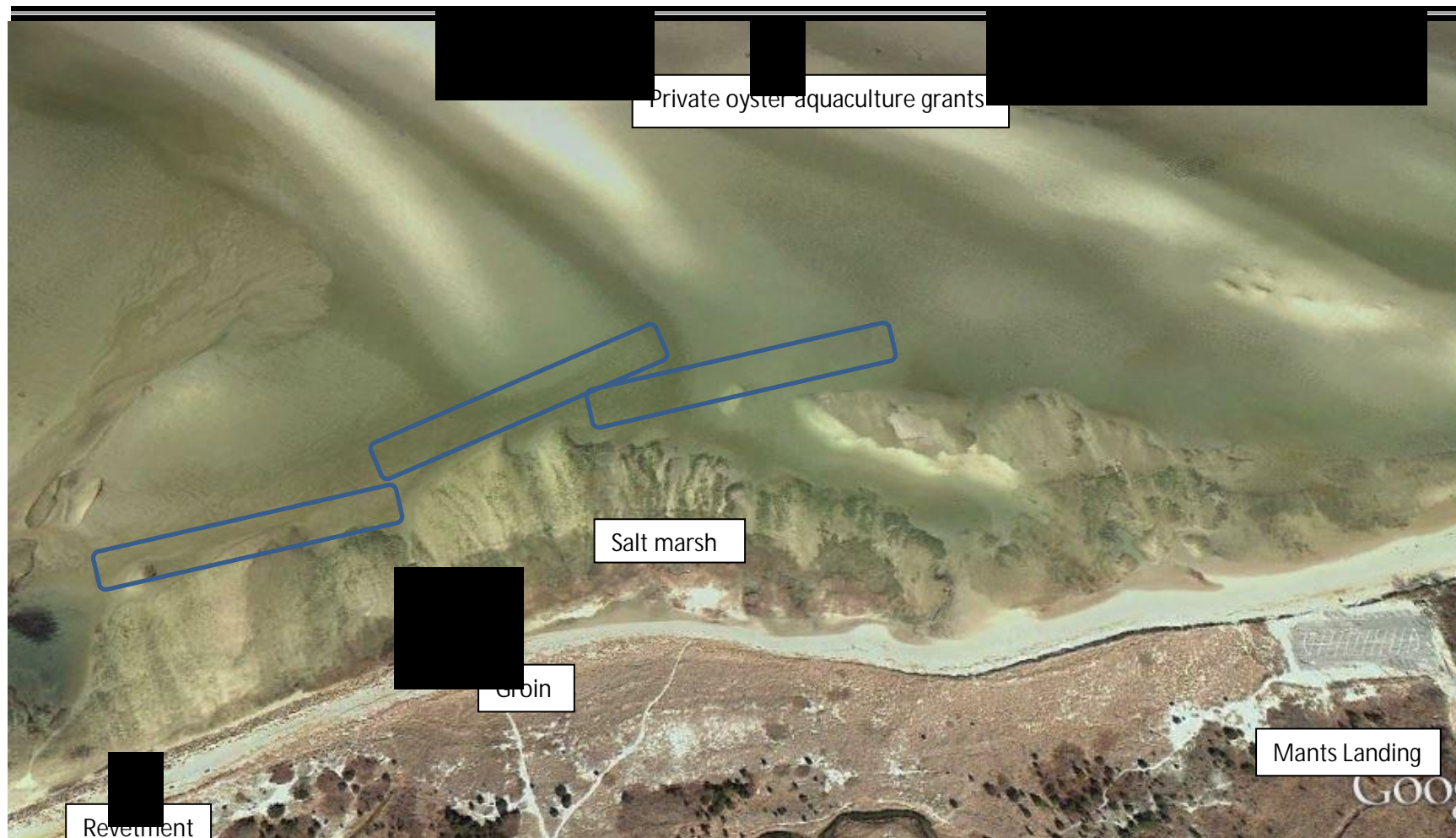
d) Construction of oyster reef. Proposed activities include purchase of materials, pre-construction staging of materials, construction, oversight and post-construction restoration.


e) Monitoring of oyster reef. This is described below.

Budget:

Site survey by a registered land surveyor (contractual):	\$5,000
Consultant for planning, design, construction and monitoring (80 hrs per year for 2 years at \$20/hr):	\$3,200
Preparation of draft and final plans for permitting (contractual):	\$15,000
Preparation of permit applications (contractual):	\$15,000
Construction materials, Oyster Castles for 1,000' of oyster reef, rental of heavy equipment, etc.:	\$200,000
Total:	\$238,200

Oyster Reef Pilot Project, Brewster MA



 Area to develop pilot oyster reef (approximately 1,000 feet linear area total)



Marsh at proposed oyster reef.



Eroding sections of marsh outside area proposed for reef pilot project.



Native set of oysters near proposed oyster reef pilot indicating favorable conditions if suitable substrate is provided.

Oyster Reef Restoration and Monitoring, Wellfleet, MA
Draft Final Report

January 30, 2011

Submitted by:

Mark Faherty, Science Coordinator

Mass Audubon, Wellfleet Bay Wildlife Sanctuary

P.O. Box 236

South Wellfleet, MA 02663

Prepared for: Massachusetts Bays Program (MBP) Research and Planning Grant,
FY2011

I. Introduction

The wild oyster reefs of Wellfleet were once so extensive that they presented navigation hazards, prompting Samuel de Champlain to name Wellfleet Harbor “Port aux Huitres” (Oyster Harbor) when he explored the area in 1606. As recently as the 1970s, state fisheries biologists counted 1000 bushels of oysters on the flats around Lieutenant Island (Curley et al 1972). Overharvest and disease took their toll on the natural reefs (Beck et al 2011), and the famous Wellfleet oyster is now mostly a farm product, grown in plastic mesh bags from purchased hatchery seed. With the disappearance of the wild reefs, many of the services they provide have also gone, including benthic-pelagic coupling (Kellogg et al 2011, Willcox 2009), water filtration (Grizzle et al 2008), shoreline stabilization (Piazza et al 2005), and providing habitat for a wide array of finfish and invertebrates, (Coen et al 2007, Peterson et al 2003, Harding and Mann 2001). While states to our south have long recognized the importance of wild reefs and have been working to restore natural oyster populations for decades, Massachusetts has not developed any significant restoration programs, with state regulators instead focusing on management of aquaculture shellfish. This project fills a longstanding need for shellfish restoration research in Massachusetts.

The **goal** of this project was to restore an oyster reef on tidal flats owned by Mass Audubon off Lieutenant Island. Our **objectives** were to catch a natural set of oysters, monitor the growth and survival of the oysters to determine which of three treatments (shell culch, Reef Balls, or Oyster Castles) worked best for catching and growing wild oysters, survey other organisms present, monitor the oysters for disease, and involve the community at all steps of the process.

Our measures of success include:

- 1) High density and survival of oysters growing on the reef. A successful reef will have multiple generations of oysters growing together, ideally covering all surfaces of the reef materials.
- 2) Increased diversity and abundance of invertebrates, fish, and birds at the restoration site relative to two control sites.
- 3) A clear permitting track for future shellfish restoration projects in MA.

Because this restoration is the first of its kind in New England, the lessons learned from our research will inform both the expansion of this project as well as any future oyster restorations in terms of:

- The best materials to use for attracting a set of oysters
 - Which materials survive winter conditions and sedimentation better
 - Which type of culch grows oysters better
- The best way to arrange those materials to ensure long-term survival of the reef
- How biodiversity changes with reef development compared to reference sites
- Levels of two common oyster diseases on the wild reef
- And, in 2012 and beyond, whether harvest is compatible with maintaining a self-sustaining reef.

II. Methods

Restoration involved deploying three common oyster growth substrates (culch, Reef Balls, Oyster Castles) in a nine-block experimental design with treatments randomly assigned within each block. The blocks are 60 feet long with 20 foot sub-blocks containing each treatment. A map of the layout of the blocks at the site is included with supporting materials below.

Both Reef Balls and Oyster castles are made from special concrete mixes pH balanced to mimic natural reef materials. Reef Balls were purchased from Reef Innovations, Inc of St. Cloud, Florida, through the Reef Ball Foundation (reefball.org). Oyster Castles were provided at no cost by Allied Concrete of Charlottesville, Virginia. Shell culch was a mix of purchased surf clam shells and a small amount of oyster shell provided by Shellfish Promotion and Tasting (SPAT), organizers of Wellfleet OysterFest.

Monitoring Activities

- i. Oyster abundance, survival, and demography: Oyster abundance, survival, and demography are being measured annually in the spring to assess winter survival and again in the fall after recruitment. The number of individual oysters is counted in a 0.25 m² quadrat placed on the culch, and total oysters are counted on a subset of the Reef Balls and Oyster Castles in each replicate block. The size distribution of oysters is estimated by measuring the length of 25 individual oysters within the 0.25 m² quadrat or on an individual reef ball or castle to the

nearest mm. To facilitate comparisons between treatments with very different shapes, arrangements, and surface areas, we converted the average counts of oysters on the balls and castles into the theoretical density of oysters possible based on how many Reef Balls and Oyster Castles could fit into a square meter.

ii. Biodiversity:

a. Organisms on the surface of the reef and the sediment. The biological community that develops in the restored oyster reef is being compared to a nearby bare tidal flat of similar sediment and elevation (“sandy reference area”) and to an existing natural oyster bed (“rocky reference area”). The method uses 20 randomly placed 1 m² quadrats within which a smaller 0.25m² quadrat is nested. The percent cover of sessile organisms on the surface of the sediment or reef (e.g., barnacles, oysters, and macroalgae) are recorded within each 1 m² quadrat using the Braun-Blanquet cover classes. The number of individuals of mobile fauna (e.g., crabs, snails) and sessile organisms (not counting encrusting macroalgae) within nested 0.25 m² quadrat is also recorded. The sampling is carried out mid-summer, when most organisms are active.

b. Infauna. The abundance of infauna in the reef and reference areas is surveyed using 20 randomly placed cores (10 cm diameter, depth of 20 cm) in the restoration area and the two reference areas. Sampling is done concurrently with the surface quadrats described above. These cores were used to characterize the sediment characteristics of the sites in year one. To assess micro scale variation in invertebrate abundance related to the presence of the restoration substrates, in 2010 cores were also taken at three locations at each treatment: within the treatment, the outside edge, and three feet outside the treatment. The cores are brought back to the lab and sieved through a 0.5 mm screen. The organisms are then picked out and preserved in alcohol for later identification by a taxonomic expert.

c. Nekton. Various methods were tested for quantifying fish use of the restoration area, including throw traps, minnow traps, snorkeling and beach seines. Lift-netting was the most promising method, and a list of fish species on the reef and adjacent unrestored area was generated with this method in 2011.

- d. Birds.* During April and May and again from July through October, an observer with a spotting scope counted birds in the restoration area and the nearby sandy reference area for ten minutes at low tide on each sample day. During the time that diving ducks are present (November through May), counts were made at high tide. The observer stays far enough away from each area so as not to disturb the birds, but close enough to allow identification.
- iii. **Sedimentation:** We anticipated that the restored reef would act as a sediment trap. We will therefore examine the effect of the restored reef on sedimentation and the types of sediments. The particle size distribution was determined in year one by collecting sediment cores (see 4b above), separating the sediments through a series of sieves into different particle size groups, and then drying and weighing each group. The sediments will be characterized again after three years of oyster growth to determine the effect of the restoration on the sediments. A series of rebar sections were installed in 2009 as references to monitor any accumulation or loss of sediments over time.
- iv. **Oyster Diseases:** We examine the oysters in our reef for the presence of Dermo and MSX annually. This aspect of the restoration is under the supervision of Dr. Roxanna Smolowitz of Roger Williams University. A minimum of 75 randomly selected individual oysters were collected once a year and examined for the diseases. Dermo testing has been carried out by staff and volunteers in the Wellfleet Bay Wildlife Sanctuary lab. For MSX, samples are sent out for histopathology testing by Dr. Smolowitz.

III. Results

Summary of Key Results

A population of between 60,000 and 250,000 oysters has been restored to the project area since the materials were placed in 2009. A clear winner emerged from the three restoration substrates tested - the Oyster Castles were the only substrate to maintain their structural integrity and to show a net increase in their oyster population each year. Invertebrate abundance and diversity has measurably increased on the project site relative to control sites and shorebird

use of the reef area has also increased. American Oystercatchers, a species of management concern in Massachusetts, now regularly feed on blue mussels that are growing at the site as a result of this project. Preliminary data indicate fish may be preferentially using the reef relative to adjacent unrestored areas, including tautog, cunner, killifish, and even squid. While we expect benefits in terms of improved water quality and increased spat recruitment on nearby commercially harvested flats, it is not possible to measure the impact of our project on these factors due to the overwhelming influence of tidal flushing in the area relative to the scale of the project.

Results to date have been communicated to various audiences, including the town of Wellfleet Shellfish Committee, the Cape Cod Natural History Conference, the New England Estuarine Research Society, the International Shellfish Restoration Conference in South Carolina, and the Northeast Aquaculture Conference and Exposition. Our advisory meetings included many who would be the players in any future restoration efforts in Wellfleet and around the Cape. Restoration biologists from multiple states have contacted us about our results, and they are particularly interested in the performance of the Reef Balls and Oyster Castles. Among the most important results of this project is clarification of what had been a thoroughly confusing permitting process for this unprecedented project for the state. There is currently no regulatory allowance for shellfish spawning sanctuaries in Massachusetts – all projects must be opened to harvest after three years under current law, despite strong evidence in the literature that harvest is not compatible with sustainable reefs (e.g. Powers 2009, Schulte et al 2009)). Since the restored reef cannot be completely protected from harvest, we have negotiated an experimental harvest plan to study the effect of different harvest levels (0%, 50%, and 100% of legal oysters) on the reef. Harvest is scheduled for summer of 2012.

A. Oyster Abundance and Survival

The materials were deployed in June of 2009, and by late summer it was clear the reef had caught a heavy set of spat. Fall oyster density surveys showed that roughly 250,000 young oysters were growing on the reef, with the culch having the highest density and abundance of the three treatments heading into the reef's first winter. Spring surveys in 2010 showed high winter mortality, particularly on the culch, reducing the overall number of oysters to around 60,000.

Surprisingly, at least 52% of the Reef Balls had broken apart over the winter, likely due to improper formulation of the concrete for surviving the freezing and thawing typical of a winter on intertidal flats in Massachusetts. None of the Oyster Castles showed any signs of breaking down. Much of the culch was dispersed by the tides or covered in sand over a two year period, burying the growing oysters and negatively affecting survival. The culch always suffered the highest winter mortality, ranging from 66 – 89% each year.

Treatment	2011 Winter Mortality (%)		
	2010	2009	Average
Culch	90	89	89.5
Reef Balls	53	46	49.5
Castles	63	57	60.0

Table 1. Winter mortality of one year-old (2010 class) and two year-old (2009 class) oysters in spring of 2011. High culch mortality is likely due to sand burying the oysters.

Good summer recruitment brought the total number of oysters on the reef close to 200,000 by fall of 2010. As of 2011 the total number of oysters on the reef is around 130,000, with the Oyster Castles having emerged as the clear winner among the three treatments in every respect: total oysters, oyster density, and average size (Table 2). In addition, the castles are the only of the three treatments to show a net increase in oysters each year (Figure 1). A separate experiment begun in 2010 sought to determine whether oyster shell or surf clam shell made the best culch for attracting and maintaining a population of oysters (Table 4). The results showed that surf clam shell caught a higher density of spat in the first year, and maintained its structural integrity better than oyster shell when exposed to tides and storms over several months. By the second year one of the oyster treatments had completely washed away. Densities were similar on the two culch types in 2011, but the surf clam shell held twice as many total oysters.

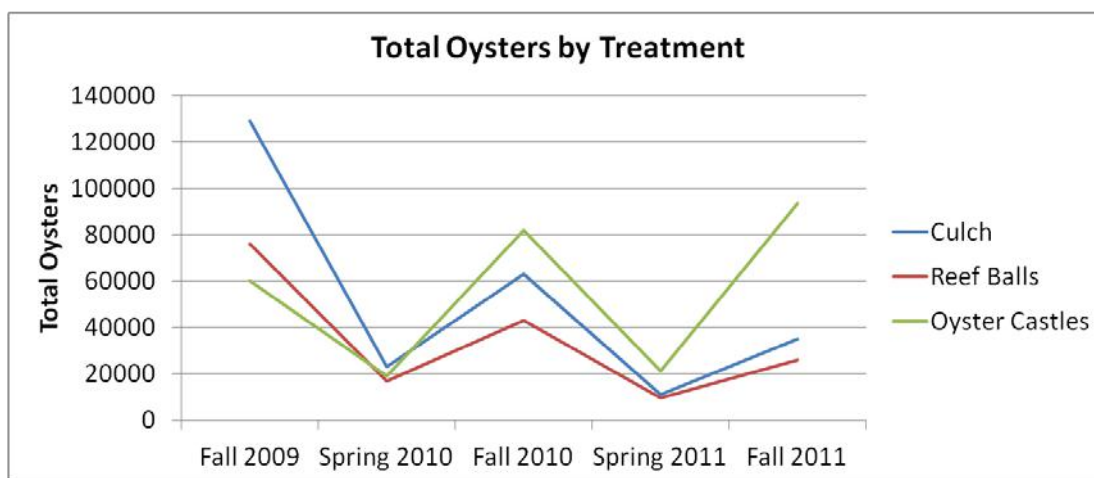


Figure 1. Estimated total oysters on the substrates through time. Winter mortality was heavy in both 2009 and 2010. The oyster castles continue to support the most oysters of the three treatments. Only the castles have shown an increase in total oysters each year.

	Oysters/unit (Actual)		Oysters/Square Meter (Theoretical)	Total Current Oysters	Avg. Size (mm)
	2011 Class	Older			
Culch	74/m ²	7/m ²	81	12000	31
Reef Balls	85/ball	22/ball	428	26000	40
Castles	137/castle	39/castle	1584	93000	45
TOTAL:				131000	

Table 2. Density and abundance of oysters by treatment, fall 2011. Theoretical densities were calculated to allow comparisons among the treatments, and reflect the density of oysters likely if the maximum number of reef balls and oyster castles were placed per square meter. Oysters over 55mm were classified as “older” and represent the 2010 and 2009 year classes combined.

Treatment	Oysters/unit			Total Current
	2010	2009	TOTAL	
Culch	12.5	4.5	17/ m ²	11,016
Reef Balls	21	18	39/ball	9,477
Castles	26	14	40/castle	21,240

TOTAL: 41733

Table 3. Density and abundance of one year-old (2010 class) and two year-old (2009 class) oysters in spring of 2011, illustrating the greatly reduced population typical of the spring counts. Units are oysters per square meter, ball, or castle.

	% Dead	Density Live Oysters	Total Live Oysters
Oyster Shell	0.69	440	3212
Surf Clam Shell	0.66	448	6541

Table 4. Density and abundance of oysters as a function of culch type. Pure treatments of oyster shell and surf clam shell culch were placed in the restoration area in 2010 to determine which culch type catches a better set of young oysters. After one year, densities of live oysters growing on the shells were similar, though the total number of oysters remaining was much higher on the surf clam piles, likely because the heavier shells of the surf clams better resisted being washed away by the tidal currents.

B. Biodiversity

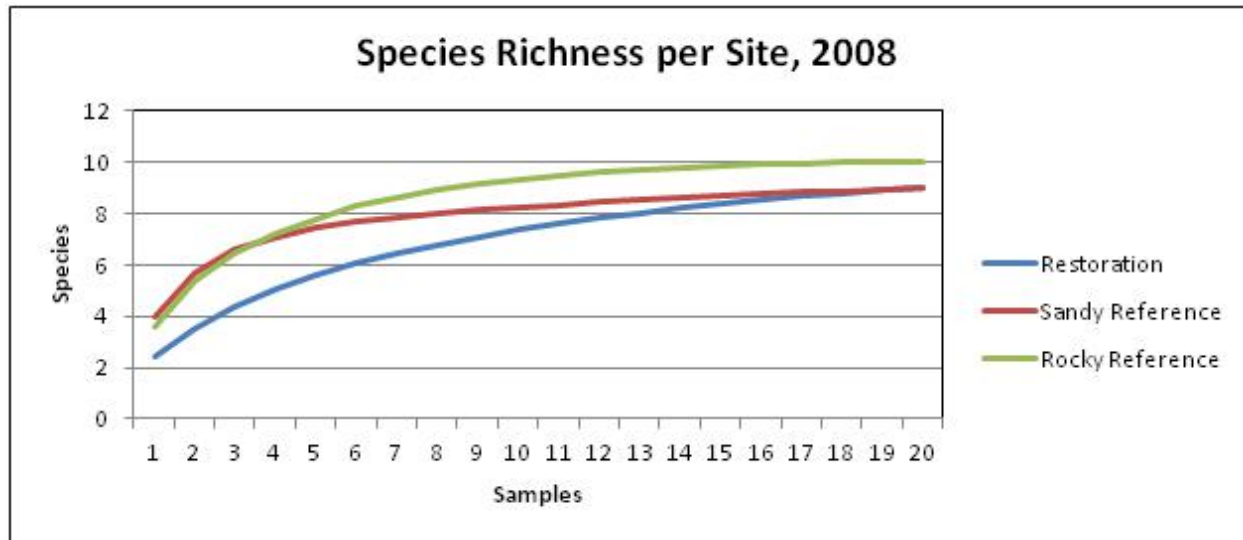
Surface Fauna

The number of organisms counted in the surface quadrats increased in the restoration area relative to the two reference areas between 2008 and 2011. Species richness was examined using resample-based species accumulation curves showing the number of species as a function of the number of samples in each area (Figure 2). In 2008, the existing oyster flat ("rocky reference area") had the highest species richness of the three areas, but by 2011 the restoration area had the highest richness. Much of the surface fauna data are still being analyzed.

Infauna

Many samples have yet to be identified to species, but the number of animals per core was quantified for the restoration area and the two reference areas. Between 2008 and 2009, the number of invertebrates per core increased in the restoration area relative to the reference areas (Figure 3). The rocky reference area had the highest number of organisms per core in 2008, but the number of organisms counted in the restoration area increased dramatically in the year following the start of the project. Cores were also taken in three locations relative to each treatment: within the treatment, at the outer edge, and 3 feet outside the treatment. The goal was to look for small scale patterns in benthic invertebrate abundance that reflected the influence of the reef materials. We had noticed that polychaetes were often easy to find both at the edges of treatments and among the culch, and this sampling scheme sought to quantify these patterns. More species per core were noted in the edge samples and in the culch samples. Average species per core was higher inside the treatments than in a bare sandy area three feet outside the treatment.

a.



b.

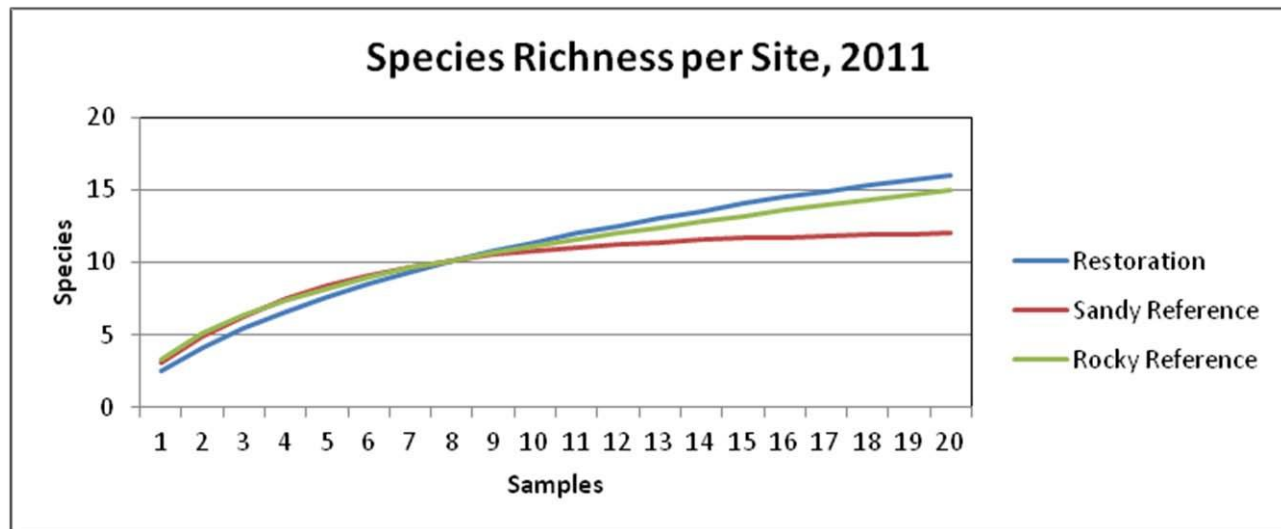
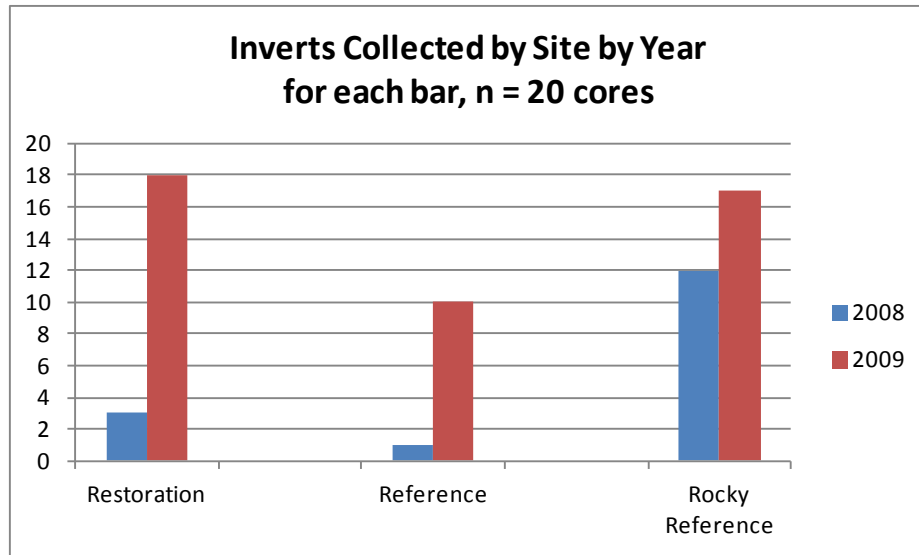


Figure 2. Biodiversity of surface fauna. Species richness presented in the form of accumulation curves (number of species of surface organisms as a function of the number of quadrats sampled) for the three survey areas in a) 2008 and b) 2011.

a.



b.

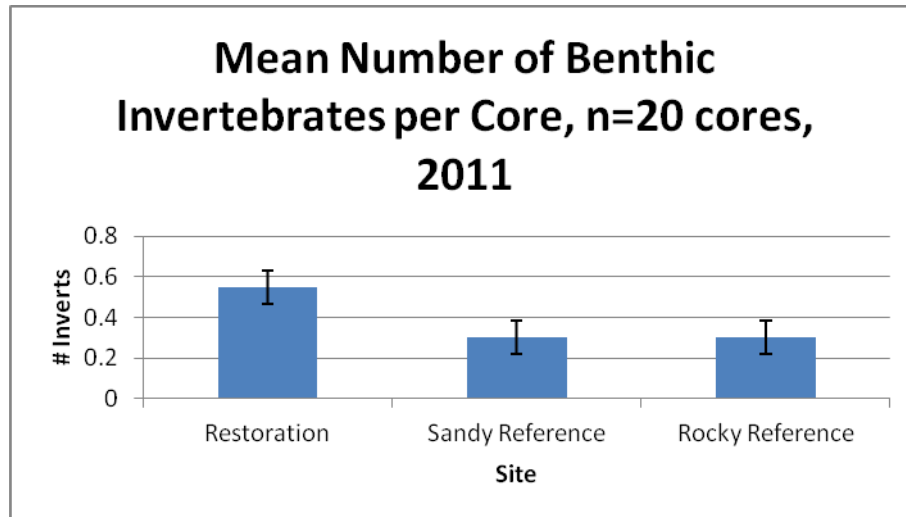


Figure 3. Mean (+1 SD) individuals of benthic invertebrates per sediment core increased in the restoration area relative to control sites between 2008 and 2009 (a), and were higher than in both reference areas in 2011 (b).

Treatment	Sample Location			Average
	Within	Edge	Outside	
Balls	1.67	1.33	0.89	1.30
Castles	1.22	1.22	1.33	1.26
Culch	2.33	3.00	1.56	2.30
Average	1.74	1.85	1.26	

Table 5. Mean invertebrate species per sample for cores taken at three locations at each treatment: within the treatment, the outside edge of the treatment, and three feet outside the treatment. The culch averaged more species per core than the other treatments, and more species per sample were found in the edge samples compared with the other locations.

Birds

Shorebird use of the restoration area increased noticeably over the course of the project. Ruddy turnstones, a species favoring hard substrates and loose shells, are often seen feeding directly on the reef. Willets and gulls feed routinely in the small pools that developed on the north side of the treatment blocks. At least two pairs of American oystercatchers, which nest nearby, feed daily during the summer on the dense concentrations of blue mussels that are growing on the site as a result of the project. Common eiders, which feed on mussels and crabs, and common loons, which feed on small fish, showed a small increase over the course of the project during the high tide surveys, though sample sizes were small.

	Mean Birds/Visit	
	Common Eider	Common Loon
2008-2009	0.2	0.2
2009-2010	0.4	0.6
2010-2011	0.7	0.7

Table 6. Abundance of two common diving waterfowl likely to benefit from increased crab, fish, and shellfish abundance on the restored reef increased slightly over the course of the project, though sample sizes were always low.

a. Mean Birds per visit		b. Mean Species per visit	
Reference	Restoration	Reference	Restoration
19.8	42.4	3.2	4.4

Table 7. Mean number of birds (a) and species (b) per visit for shorebird surveys, data combined across years.

Nekton

Lift nets (Rozas 1992, Wenner 1996) were deployed over all three treatment types and the adjacent sandy reference area. Results from the three treatments were combined since the primary goal was comparing the restored reef with an unrestored reference area. Nets consisted of a 68' by 7' beach seine stretched around a frame of 10' pvc pipes. Photos can be seen in the following online gallery: [Lift net fish sampling, Summer 2011](#). There were few tides during the summer allowing sufficient time to use this method, so sampling opportunities were limited. Multiple attempts failed when strong tidal currents dislodged the gear. The results are approximate due to the resulting low and uneven sample sizes (more samples were collected over the reef), but they suggest that more fish, in terms of both species and individuals, may use the reef compared with an unrestored sand flat nearby.

	Species/Sample	Individuals/Sample
Restoration (n=5)	3.8	821
Reference (n=2)	2.5	621

Table 8. Number of species and individual nekton per sample collected using lift-nets over the restored reef and an adjacent unrestored sand flat.

C. Sedimentation

Nine sediment monitoring stations (locations can be seen in Figure 5) were checked periodically to measure the sand level relative to when the stations were installed in 2009. PVC monitoring stations had been installed prior to 2009 but did not survive the winter, so we replaced them with rebar sections marked with a length of rope and a float. Of these, two disappeared by 2010. On average the seven remaining stations showed erosion, with a cumulative loss of 8 cm of sand when data were summed across all stations. However, stratification was strong, with high levels of *accretion* in the more seaward and middle stations adjacent to the restoration area, and strong *erosion* in the

more landward three stations. The accretion in the lower stations is consistent with our observations of accumulating sand on the experimental treatments.

	Restoration	Sandy
Alewife	96	
Atlantic	3827	1223
Striped Killifish	102	1
Winter	1	
Cunner (juv)	6	
Butterfish	39	
Shore Shrimp	++	++
Sand Shrimp	++	++
Squid	4	
Sea Robin (juv)	1	
Northern	5	4
Tautog (juv)	1	
Bay Anchovy	1	

Table 9. List of nekton species trapped during lift net sampling in 2011. Shrimp were abundant in all samples but were not counted. Uneven sample sizes prevent statistical comparison between treatment and control, but the list of species found on the restored reef and reference area is presented for general interest.

STATION	Change
Deep3	28
Deep2	4
Deep1	20
Mid3	25
Mid2	5
Mid1	lost
Shallow3	-80
Shallow2	-10
Shallow1	lost

Table 10. Sediment monitoring stations and the change in sand level since fall 2009. Deep stations are closer to the restoration area, while shallow stations are closer to land (see Figure 6).

D. Disease

Dermo

A sample of roughly 76 oysters from the restored reef was tested in each year using Thioglycollate methods (Ray 1952). Oyster tissue was sampled, incubated in a sterilized growth medium for a week, then examined under a microscope for presence of the disease organism. Upper and lower refer to location in the restoration area, with upper referring to the three most landward treatments and lower referring to the three most seaward treatments. Results were similar in 2009 and 2010 – less than half of the animals showed infection, and infection intensities were always low as indicated by few disease spores per slide.

	Upper	Lower
Intensity	0.00	0.00
Prevalence	0.42	0.39
# infected	16	15

Table 11. Results from Dermo testing of oysters from the upper and lower reef in 2011. Results indicated about 40% of the animals showed infection (prevalence), and the infection intensities were very low as indicated by few spores noted per sample (intensity). Infections this light are believed to be well below the mortality threshold for this disease. Results in other years were similar.

MSX

No MSX was detected by Dr. Roxanna Smolowitz in 164 animals collected from the restoration site in 2010 and 2011. See Appendix A. Methods are described in Kim et al (2006).

IV. Summary of Community Involvement and Outreach Activities

- We convened Project Advisory Committee 3-4 times during project development in 2008-2009 to discuss Experimental Design prior to submittal to Division of Marine Fisheries. These meetings included regular attendance by 7-8 individuals of the Wellfleet shellfishing community, who are members of the Committee and helped to develop the consensus-based Experimental Design, which was approved by the Division of Marine Fisheries. Discussions included pros and cons of various experimental substrates.
- Each October we had a table at the Wellfleet OysterFest, with over 20 - 30,000 people estimated to attend over these two day annual events celebrating the

Wellfleet Oyster and the community of fishermen who harvest them. We also presented lectures about the project at two of the last three OysterFests.

- Presentation by Mark Faherty at annual New England Estuarine Research Society meeting in Provincetown, MA in November 2010.
- Mark presented a poster at the International Shellfish Restoration Conference in Charleston, South Carolina in November 2010.
- Mark presented at the Northeast Aquaculture Conference and Expo in Plymouth, MA
- Mark Faherty and Boze Hancock of TNC presented at a panel discussion at the Mass Association of Conservation Commissions meeting at The College of the Holy Cross in Worcester on March 5.
- Mark presented a talk on the project at the South Shore Natural Science Center in Norwell, MA. The audience included many interested in restoring oysters in the North River estuary and Duxbury Bay.
- Boze Hancock gave a public lecture on oyster restoration at Wellfleet Bay Wildlife Sanctuary in August 2008 discussing the historical extent of oyster reefs, the reasons for their disappearance, quantitative data on the ecological and economic services the reefs provide, and examples of successful restorations in other states, ultimately linking all of this to the Wellfleet project.
- Our education staff teaches a lesson on oyster reef habitat and oyster reef restoration in Eastham and Wellfleet schools.
- A guided tour of the reef was offered as an auction item during our “Wild Wild Wellfleet” Fundraiser in 2010, and the winning bidders included the publishers of Edible Cape Cod magazine and other local food experts.
- We offered a guided tour for the Lieutenant’s Island Homeowners Association. The restoration site is on the west side tidal flats adjacent to some of the homes on the island.
- We continue to offer many public walks to the restoration site in addition to the various speaking engagements at conferences and festivals covered elsewhere in the document.

V. Supporting Materials

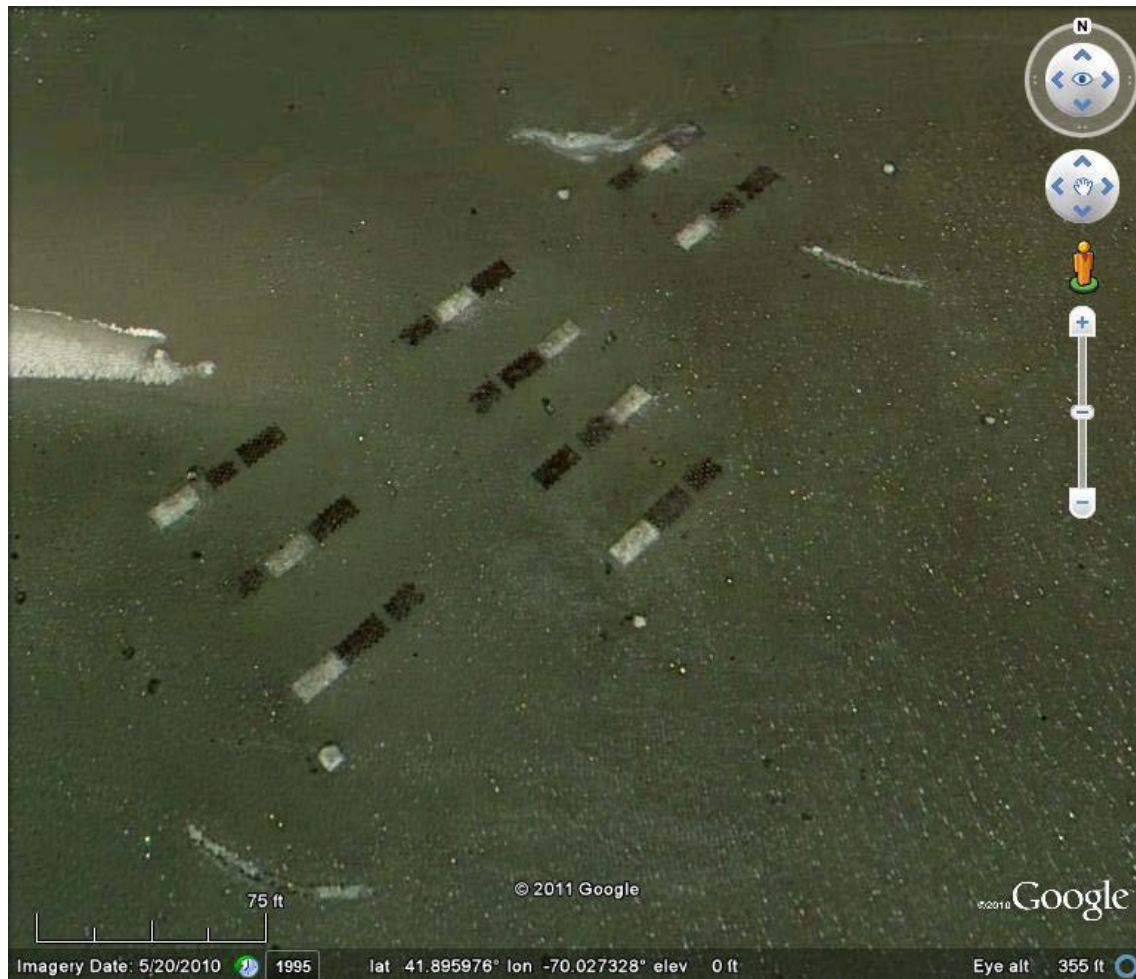


Figure 4. Google Earth image of the restoration area showing the 9 experimental blocks. Culch (white areas), Reef Balls (smaller sub-rectangles, 27 per block), and Oyster Castles can be distinguished in the photo.

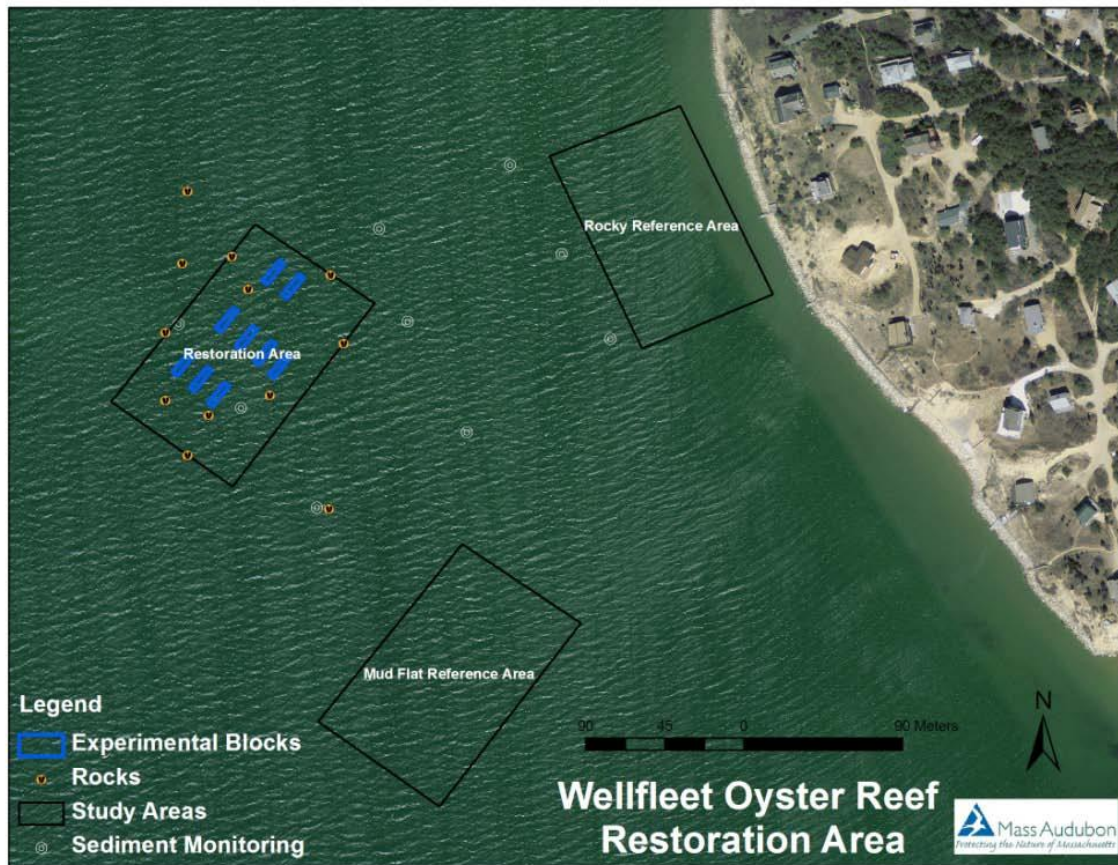


Figure 5. Map of the larger study area showing the restoration area and two reference areas. Biodiversity data was collected in the two reference areas in addition to the restoration area.



Figure 6. Top photo shows a block with the three randomly assigned treatments just after set-up. The bottom photo shows the extensive, oysterless sand flats that dominated the site before restoration.



Figure 7. Top and Bottom: Oyster Castles, the most successful of the three treatments, covered in oysters of multiple ages. October 2011.



Figure 8. Top and Bottom: While most of the culch was dispersed or buried, patches remain that support adult oysters. October 2011.

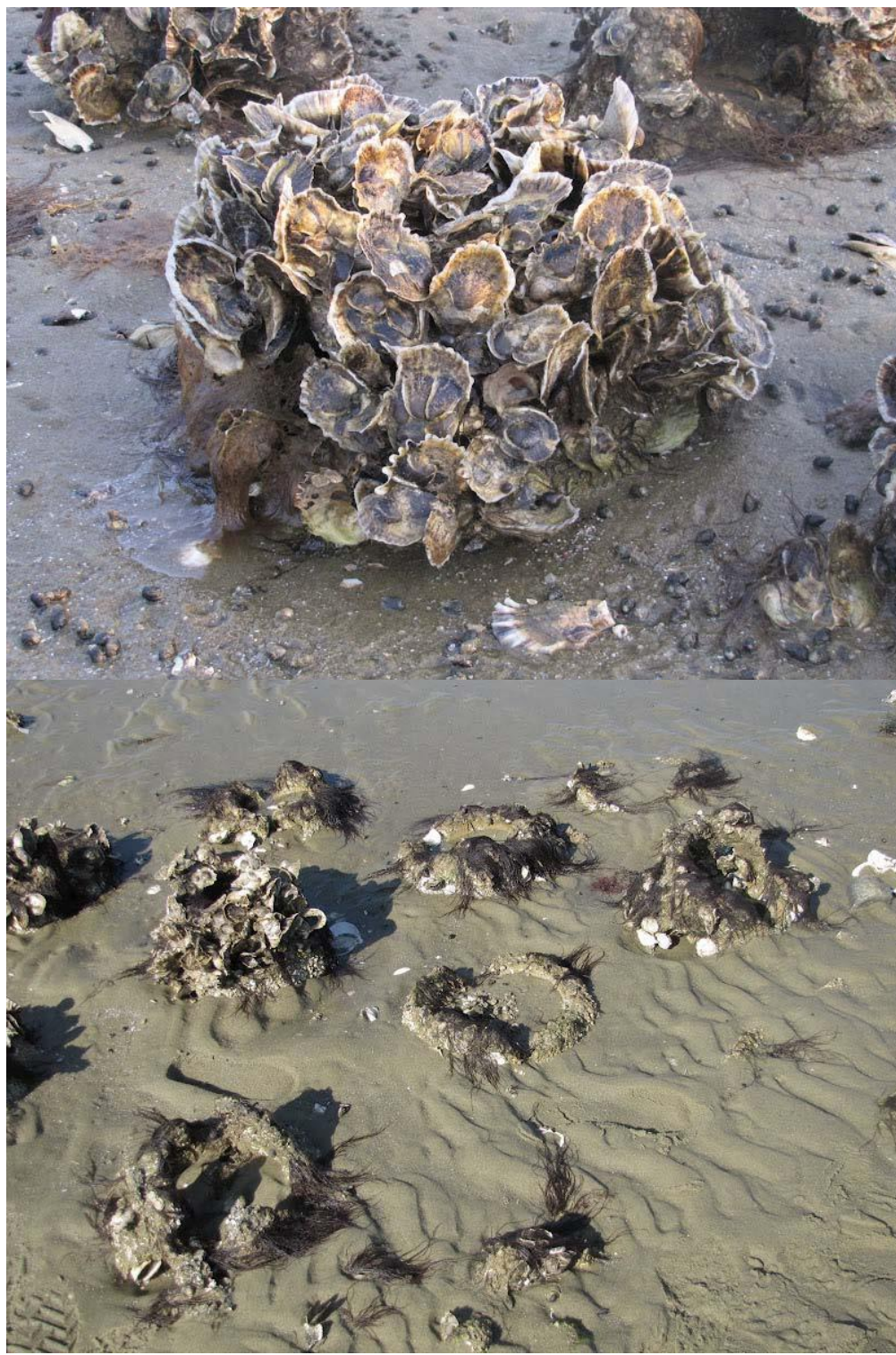


Figure 9. Top: A Reef Ball covered in oysters. Bottom: Some of the roughly 75% of Reef Balls showing partial to complete disintegration. October 2011.

Earned Media Coverage:

[National coverage on NPR's "Living on Earth Series"](#)

10/17/09 Cape Cod Times: [Article about Wellfleet Oyster Fest which also mentions the oyster restoration.](#)

11/24/09 Provincetown Banner: [Story on the State of Wellfleet Harbor Conference, including our oyster reef talk](#)

Mish Michaels of WBZ-TV Boston visited the project site and the story aired on July 1 during the evening news.

Photo Galleries:

[The Reef in October 2011](#)

[Lift net fish sampling, Summer 2011](#)

[The Reef in October 2010](#)

[Post-winter Reef, March 2010](#)

[American Oystercatchers on the Reef, 2010](#)

[Oysters Growing on Experimental Materials, September 2009](#)

[Setting up the Reef, June 2009](#)

[Culch Pilot Study Set Up, 2008](#)

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Appendix A. MSX Disease Testing Results, 2011

Submitted by Dr. Roxanna Smolowitz, Roger Williams University Aquatic Diagnostic Laboratory

Oysters were divided into four groups: upper one-year olds, lower one-year olds, upper two-year olds, lower two-year olds. No evidence of MSX was found, but full official results are included for completeness. Dr. Smolowitz also noted histological evidence of Dermo infections consistent with our lab results presented above.

SHELLFISH PATHOLOGY REPORT

RWU Case No. 3717

Date of Report: Dec. 22, 2011

Source of Animals: M. Faherty, Audubon Society

Species: *Crassostrea virginica*

Location of Collection: Wellfleet Bay Wildlife Sanctuary/upper 1 yr olds

Collection Date: 10/12/2011

Collected By: M. Faherty

Date Processed at RWU: 10/12/2011

No. of animals examined grossly: 25

No. of animals examined microscopically: 25

No. of animals examined using Thioglycollate culture techniques: 0

Gross description of animals:

a. Weight: averaged 35.8 g

b. Shell height: averaged 73 mm

c. Gross appearance: recent set spat attached to shell surface (affects weight measurement)

1. Animals processed histologically were:

a. randomly selected from the upper 1 year olds

2. Histological Findings:

a. Parasites:

Group	Parasite Species	Percent infected
Bacteria	Chlamydia/Rickettsia	0
Fungi		0
Protozoa	QPX	0
	Dermo (<i>Perkinsus</i> sp.)	24%
	MSX	0
	SSO	0
Metazoa		0
Helminths		0
Arthropoda		0

b. Neoplasia

Hematopoietic Leukemia	0
Gonadal Tumor	0
Other tumor:	0

c. Other histological findings:

6/25 animals showed rare Dermo organisms in tissues of the gill and digestive gland. Associated inflammation is mild. One female shows a probable microsporidial infection (similar findings to those found in *Steinhausia* sp. infections) in the retained eggs in the inflamed gonadal tubules.

Gross and histological Summary:

Dermo identification using histology is less sensitive than methods of detection using Thioglycollate culture techniques. Microsporidial infections of oyster eggs is considered an incidental finding.

Comments:

Only mild Dermo infections were noted histologically. No MSX infections were identified.

Roxanna Smolowitz, DVM
Aquatic Diagnostic Laboratory
Ph: 401-254-3299
Email: rsmolowitz@rwu.edu

SHELLFISH PATHOLOGY REPORT

RWU Case No. 3718

Date of Report: Dec. 22, 2011

Source of Animals: M. Faherty, Audubon Society

Species: *Crassostrea virginica*

Location of Collection: Wellfleet Bay Wildlife Sanctuary, lower 1 year olds

Collection Date: 10/12/2011

Collected By: M. Faherty

Date Processed at RWU: 10/12/2011

No. of animals examined grossly: 23

No. of animals examined microscopically: 23

No. of animals examined using Thioglycollate culture techniques: 0

Gross description of animals:

a. Weight: averaged 38.2 g

b. Shell height: averaged 65.5mm

c. Gross appearance: Many show new spat cemented to the surface of the animals examined

Histological Evaluation:

1. Animals processed histologically were:

a. randomly selected from the lower 1 year olds

2. Histological Findings:

a. Parasites:

Group	Parasite Species	Percent infected
Bacteria	Chlamydia/Rickettsia	0
Fungi		0
Protozoa	QPX	0
	Dermo (<i>Perkinsus</i> sp.)	9%
	MSX	0
	SSO	0
Metazoan		0
Helminths (polychaete)		4%
Arthropoda		0
b. Neoplasia		
	Hematopoietic Leukemia	0

Gonadal Tumor	0
Other tumor:	0

c. Other histological findings:

2/23 animal show very low Dermo infections with very mild associated inflammation. One animal shows a cross section of a turbellarian-like organism in the stomach lumen. One animal shows a focal pocket of inflammation associated with a possible section of a polychaete in the area between the shell and mantle.

Gross and histological Summary:

Dermo identification using histology is less sensitive than methods of detection using Thioglycollate culture techniques. Turbellarian infestation in the lumen of the stomach are incidental finding when only 1 or 2 are identified in histology sections. The occurrence of a pocket of inflammation between the mantle and shell associated with a polychaete worm indicates the probable polychaete borrowed through the shell into the underlying tissue. This is rare, but does occasionally happen. Usually the oyster “walls off” the intrusion into its soft tissues and in most cases is not severely affected. Polychaete (mud worm) infestations of oyster shells are common.

Comments:

Only mild Dermo infections were noted histologically. No MSX infections were identified.

Roxanna Smolowitz, DVM
Aquatic Diagnostic Laboratory
Ph: 401-254-3299
Email: rsmolowitz@rwu.edu

SHELLFISH PATHOLOGY REPORT

RWU Case No. 3719

Date of Report: Dec. 22, 2011

Source of Animals: M. Faherty, Audubon Society

Species: *Crassostrea virginica*

Location of Collection: Wellfleet Bay Wildlife Sanctuary, upper 2 year olds

Collection Date: 10/12/2011

Collected By: M. Faherty

Date Processed at RWU: 10/12/2011

No. of animals examined grossly: 19

No. of animals examined microscopically: 19

No. of animals examined using Thioglycollate culture techniques: 0

Gross description of animals:

- a. Weight: averaged 62.1 g
- b. Shell height: averaged 94.3 mm
- c. Gross appearance: Many show new spat cemented to the surface of the animals examined

Histological Evaluation:

1. Animals processed histologically were:
 - a. randomly selected from the upper 2 year old population

2. Histological Findings:

a. Parasites:

Group	Parasite Species	Percent infected
Bacteria	Chlamydia/Rickettsia	0
Fungi		0

Protozoa	QPX	0
	Dermo (<i>Perkinsus</i> sp.)	10.5%
	MSX	0
	SSO	5%
Metazoa		0
Helminths (polychaete)		
Arthropoda		0

b. Neoplasia

Hematopoietic Leukemia	0
Gonadal Tumor	0
Other tumor:	0

c. Other histological findings:

2/19 animals were noted to contain low levels of dermo in gill and the body. 1/19 contained one SSO-like organisms in the gill connective tissues

1/19 animals showed multifocal infestation with Sphenophyra-like protozoans causing hyperplasia and mild necrosis of associated gill water tubular epithelium

1/19 animals showed a turbellarian flatworm cross-section in the gastric lumen

2/19 showed multifocal inflammation of digestive gland ducts but no cause was noted.

Gross and histological Summary:

Dermo identification using histology is less sensitive than methods of detection using Thioglycollate culture techniques. It is likely that the 2 animals that showed inflammation of the digestive gland were also infected by Dermo organisms that were

not seen histologically. Turbellarian infestation in the lumen of the stomach are incidental finding when only 1 or 2 are identified in histology sections. Splenophra-like (ciliate) infestation of the gills is not uncommon, but hyperplasia to the extent seen in this animal in association with that infestation is uncommon. This finding suggests that more organisms were present in life and that they were washed out of the tubules during processing (they are not firmly attached to the epithelium). Because only one animal appeared affected by the Splenophra ciliates and the areas of infestation were not numerous, this is considered an incidental finding. One SSO-like organism was identified in one animal. This is an extremely low level infection. SSO is not directly infective and so this infection may not become a problem in following years. But the population should be closely watched for any mortality in the coming May/June time period. The organisms are only abundant and cause mortality if there are many spread to the oysters from the other host (no one knows what that other host may be at this time).

Comments:

Only mild Dermo infections were noted histologically. No MSX infections were identified. One SSO infected animal was identified.

Roxanna Smolowitz, DVM
Aquatic Diagnostic Laboratory
Ph: 401-254-3299
Email: rsmolowitz@rwu.edu

SHELLFISH PATHOLOGY REPORT

RWU Case No. 3720

Date of Report: Dec. 22, 2011

Source of Animals: M. Faherty, Audubon Society

Species: *Crassostrea virginica*

Location of Collection: Wellfleet Bay Wildlife Sanctuary, lower 2 year olds

Collection Date: 10/12/2011

Collected By: M. Faherty

Date Processed at RWU: 10/12/2011

No. of animals examined grossly: 25

No. of animals examined microscopically: 25

No. of animals examined using Thioglycollate culture techniques: 0

Gross description of animals:

- a. Weight: averaged 52.3 g
- b. Shell height: averaged 79.8 mm
- c. Gross appearance: Many show new spat cemented to the surface of the animals examined

Histological Evaluation:

1. Animals processed histologically were:

- a. randomly selected from the lower 2 year olds

2. Histological Findings:

a. Parasites:

Group	Parasite Species	Percent infected
Bacteria	Chlamydia/Rickettsia	0
Fungi		0
Protozoa	QPX	0
	Dermo (<i>Perkinsus</i> sp.)	20%
	MSX	0
	SSO	0
Metazoan		0

Helminths (polychaete)

Arthropoda	0
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b. Neoplasia

Hematopoietic Leukemia	0
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Gonadal Tumor	0
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Other tumor:	0
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c. Other histological findings:

5/25 animals show Dermo infections histologically. An additional 4/25 animals show inflammation that is suggestive of Dermo infections, but no organisms were identified in these animals histologically. 2/25 Show mild inflammation in the gonadal tubules with low numbers of degenerative eggs (no *Steinhausia* sp. organisms were noted in these animals).

Gross and histological Summary:

Dermo identification using histology is less sensitive than methods of detection using Thioglycollate culture techniques. Mild degeneration of retained eggs were noted in the gonadal tubules. Early forms of *Steinhausia* sp. are often not identified, but degeneration of eggs in the gonadal tubule lumens post-spawning can be unrelated to *Steinhausia* sp. infection.

Comments:

Only mild Dermo infections were noted histologically. No MSX or SSO infections were identified.

Roxanna Smolowitz, DVM
Aquatic Diagnostic Laboratory
Ph: 401-254-3299
Email: rsmolowitz@rwu.edu

Engineered Plans: Table of Contents

1. Implementation of Final Green Stormwater Management for Betty's Curve on Route 6A
2. Retreat of Breakwater Beach Public Parking Lot, Restoration of Coastal Dune and Installation of Green Stormwater Management Controls

Betty's Curve Stormwater

Summary

A stormwater mitigation assessment project for Paines Creek and the Stony Brook Watershed was completed during fiscal year 2007 as part of the Coastal Zone Management Coastal Nonpoint Source (NPS) grant program. The Stony Brook subwatershed (located within the Cape Cod Watershed) in Brewster extends from its headwaters in Walkers Pond and Slough Pond down through Upper Mill Pond, Lower Mill Pond, along Stony Brook, and into Paines Creek (the tidal estuary to Stony Brook) which discharges into Cape Cod Bay. Walkers Pond, Upper Mill Pond and Lower Mill Pond are listed on the Massachusetts Year 2008 Integrated List of Waters as Category 5 waters or "waters requiring a TMDL." The watershed also contains an important herring run and rare species habitat. The primary pollutants of concern in stormwater runoff within the Stony Brook Watershed are suspended solids, sediments, pathogens/bacteria and nutrients. The report was developed with funding assistance from the American Recovery and Reinvestment Act Funds from the Environmental Protection Agency (EPA) to the Massachusetts Department of Environmental Protection under Section 604(b) of the Clean Water Act.

This assessment project identified four priority sites and is listed as follows, in order of stormwater BMP implementation priority:

1. Stony Brook Mill Site
2. Route 6A Triangle (Intersection with Lower Road and Paines Creek Road)
3. Paines Creek Road South of Route 6A intersection
4. Paines Creek Road North of the Route 6A intersection

The Stony Brook Mill Site (Site No. 1) was funded through a fiscal year 2008 CZM Coastal Pollutant Remediation (CPR) grant for final design and Best Management Practices (BMPs) were implemented with funding assistance from the s.319 NPS grant program.

The two priority sites: Route 6A Triangle (Site No. 2) and Paines Creek Road North of the Route 6A intersection (Site No. 4) were funded with assistance from a fiscal year 2009 604(b) Water Quality Management Planning Grant Program assisted by the American Recovery and Reinvestment Act (ARRA). The project goals were to develop a preliminary design for stormwater collection improvements and infiltration facilities as its primary means of treatment for the Paines Creek Road North of the Route 6A intersection site.

The Paines Creek Road sites #3 and 4, were later implemented through ARRA funding by NCRS, with a 25% match provided by the Town.

The report is attached. This phase of the project is updated and described herein.

The Betty's Curve/former Jolly Whaler property was purchased by the Town in 2005 at cost near \$1 million. The old trailer park/cottages were removed (undeveloped) and the land was dedicated to conservation and water protection. This property was identified as a priority stormwater remediation site in the Town's 2006 NPDES Small MS4 General Permit Annual Report.

The overall purpose of the design is to use the Betty's Curve site as a means of effective stormwater treatment by constructing a wetland type, naturalistically functioning, stormwater runoff renovation ecosystem with native plantings. Runoff renovation will be achieved through the use of multiple pathways for the runoff water that include drain inlets with sumps for heavy sediment dropout, collection and pooling of runoff in shallow and deep water pools and passage of runoff through dense plant growth. These systems have been designed to maintain an extended flow path from points of runoff entrance to the pond/wetland from the piped collection points to the point of outlet from the system into the natural receiving coastal waters.

The main findings are:

- Work began in June 2007 and resulted in a conceptual design with a preliminary construction cost of \$235,000
- Town decision-making process selected “Naturalistically Undulating 2” as the preferred concept for 50% design
- Updated construction cost for this 50% design was \$350,000 (2010 costs rounded to 2 significant digits) (Detailed Cost Estimate is provided in Appendix B of the Final Report)

When these costs are updated to 2014 costs at ~3% escalation per year, the construction cost becomes \$390,000.

When these costs are updated to an expected 2016 construction period (at ~3% escalation per year), the construction cost becomes \$410,000.

Design and Permitting is typically estimated at 10 to 12% of construction cost. The engineer estimates a design budget of \$40,000. Design and Permitting includes:

- • Final design
- • Reviews with the Town (1 or 2 workshops) and coordination with key staff and Department Heads
- • Presentation to BOS
- • Wetland permitting
- • MassDOT permitting
- • Development of bid ready documents (plans and specs)
- • Administration support with the funding agency

Engineering services during construction is typically estimated at 12 to 15% of construction, or a budget of \$50,000. These services include:

- • Advertisement in Central Register, bidding, and evaluation of the apparent low bidder
- • Shop drawing review
- • Review and administration of payment applications by the General Contractor
- • General construction management
- • Onsite inspection at key points in construction (This is important for this type of project)
- • Administration support with the funding agency
- • Development of record drawings
- • Project closeout

This would sum to a Total project Cost Estimate of \$500,000.

The engineer would be GHD, in Hyannis, Massachusetts, led by Jessica Janney who has led all of our stormwater and wetland projects in Brewster. She will be supported by Sandy Tripp who is our other stormwater lead currently working on stormwater projects in Provincetown and Orleans. Jim Fosdick and Jim O'Brien are the two designers/CAD and GIS specialists that will be developing the drawings (They are the 2 designers that have developed all our stormwater and wetland projects in Brewster.)



FINAL Paines Creek and Stony Brook Watershed Stormwater Mitigation Project Report 2009-03/ARRA 604

Town of Brewster, Massachusetts





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Appendix B	Design Concepts, Engineer's Estimates of Costs, and May 14, 2010 Meeting Minutes
Appendix C	Board of Selectmen Presentation of Project, June 21, 2010
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Stormwater Handbook Excerpts

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Figure 1 Paines Creek and Stony Brook Watershed Restoration Project Summary

Figure 2 Paines Creek and Stony Brook Watershed Restoration Project Summary Detail



Executive Summary

This report is a summary of the preliminary stormwater improvements designs developed with funding assistance from the American Recovery and Reinvestment Act Funds from the Environmental Protection Agency (EPA) to the Massachusetts Department of Environmental Protection under Section 604(b) of the Clean Water Act.

A stormwater mitigation assessment project for Paines Creek and the Stony Brook Watershed was completed during fiscal year 2007 as part of the Coastal Zone Management Coastal Nonpoint Source (NPS) grant program. The Stony Brook subwatershed (located within the Cape Cod Watershed) in Brewster extends from its headwaters in Walkers Pond and Slough Pond down through Upper Mill Pond, Lower Mill Pond, along Stony Brook, and into Paines Creek (the tidal estuary to Stony Brook) which discharges into Cape Cod Bay. Walkers Pond, Upper Mill Pond and Lower Mill Pond are listed on the Massachusetts Year 2008 Integrated List of Waters as Category 5 waters or "waters requiring a TMDL." The watershed also contains an important herring run and rare species habitat. The primary pollutants of concern in stormwater runoff within the Stony Brook Watershed are suspended solids, sediments, pathogens/bacteria and nutrients.

The CZM assessment project identified four priority sites of which two are the focus of this grant work and report. The first is the Route 6A Triangle (Site No. 2). The overall purpose of the design is to use the triangular site as a means of effective stormwater treatment by constructing a wetland type, naturalistically functioning, stormwater runoff renovation ecosystem with native plantings. Runoff renovation will be achieved through the use of multiple pathways for the runoff water that include drain inlets with sumps for heavy sediment dropout, collection and pooling of runoff in shallow and deep water pools and passage of runoff through dense plant growth. These systems have been designed to maintain an extended flow path from points of runoff entrance to the pond/wetland from the piped collection points to the point of outlet from the system into the natural receiving coastal waters. Six design concepts were developed as outlined in the report and were discussed with Town stakeholders. The guidance to proceed on a design with natural features which would mirror the surrounding environment was given by the Town and the "Naturalistically Undulating 2" design concept was developed further into a 50% design as funded by this grant.

The second site which is the focus of this grant work and report is the Paines Creek Road – North of the Route 6A Intersection Site (Site No. 4). At this site untreated runoff enters directly into Paines Creek at a small paved boat launch in addition to a paved scupper that directs untreated runoff into the wetland that abuts Wing Island. The drainage area has no catch basins or drainage structures of any type. A design was developed to collect stormwater runoff and infiltrate it prior to it reaching Paines Creek. Paines Creek beach is a popular Town beach and has impacted water quality due to untreated stormwater runoff from Paines Creek Road.

The overall outcome of this project is successful in terms of design. The Paines Creek Road North of the Route 6A Intersection (Site No. 4) was submitted to the United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) Cape Cod Water Resources Restoration Project for grant money to complete the final design of this area and construction of stormwater improvements. This area was selected by the NRCS and will be remediated during 2011.



The Route 6A Triangle site (Site No. 2) now has a delineated preliminary site plan which represents a functioning stormwater management system that displays a naturalistic aesthetic component and incorporates a potentially accessible landform for an area of the community adjacent to coastal wetlands. This plan provides opportunity for public access and the installation of signage informing visitors about the importance of stormwater management for the health of Cape Cod's coastal ecosystems.

Figure 1 provides a project summary of the Paines Creek and Stony Brook Watershed Restoration to date and Figure 2 provides an aerial view of Sites No. 2 and 4 with the 50% design layers.



Disclaimer/Acknowledgement of Support

This project has been financed partially with American Recovery and Reinvestment Act Funds from the Environmental Protection Agency (EPA) to the Massachusetts Department of Environmental Protection (the Department) under Section 604(b) of the Clean Water Act. The contents do not necessarily reflect the views and policies of EPA or of the Department, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.



1 Introduction

1.1 Background

A stormwater mitigation assessment project for Paines Creek and the Stony Brook Watershed was completed during fiscal year 2007 as part of the Coastal Zone Management Coastal Nonpoint Source (NPS) grant program. The Stony Brook subwatershed (located within the Cape Cod Watershed) in Brewster extends from its headwaters in Walkers Pond and Slough Pond down through Upper Mill Pond, Lower Mill Pond, along Stony Brook, and into Paines Creek (the tidal estuary to Stony Brook) which discharges into Cape Cod Bay. Walkers Pond, Upper Mill Pond and Lower Mill Pond are listed on the Massachusetts Year 2008 Integrated List of Waters as Category 5 waters or "waters requiring a TMDL." The watershed also contains an important herring run and rare species habitat. The primary pollutants of concern in stormwater runoff within the Stony Brook Watershed are suspended solids, sediments, pathogens/bacteria and nutrients.

This assessment project identified four priority sites and is listed as follows, in order of stormwater BMP implementation priority:

- 1) Stony Brook Mill Site
- 2) Route 6A Triangle (Intersection with Lower Road and Paines Creek Road)
- 3) Paines Creek Road South of Route 6A intersection
- 4) Paines Creek Road North of the Route 6A intersection

The Stony Brook Mill Site (Site No. 1) was funded through a fiscal year 2008 CZM Coastal Pollutant Remediation (CPR) grant for final design and Best Management Practices (BMPs) were implemented with funding assistance from the s.319 NPS grant program.

The two priority sites: Route 6A Triangle (Site No. 2) and Paines Creek Road North of the Route 6A intersection (Site No. 4) were funded with assistance from a fiscal year 2009 604(b) Water Quality Management Planning Grant Program assisted by the American Recovery and Reinvestment Act (ARRA). The project goals are to develop a preliminary design for stormwater collection improvements and infiltration facilities as its primary means of treatment for the Paines Creek Road North of the Route 6A intersection site.

The Route 6A Triangle includes the three intersections of Route 6A, Lower Road and Paines Creek Road. Much of the runoff from these highly traveled roads and existing drainage infrastructure (via piping) is directly discharged into Stony Brook. At the intersection of Route 6A and Lower Road (northwest corner of the triangle), there are several Massachusetts Department of Transportation (MassDOT) maintained catch basins that pipe untreated stormwater to a direct discharge into Stony Brook. There is a network of leaching systems in place at the other intersections of the "triangle" that do provide some stormwater treatment.

The Nevin's parcel was purchased by the Town in 2005, acquiring and removing the former Jolly Whaler Motel and trailer park at "Betty's Curve" on Route 6A, creating a scenic view across the Stony Brook Marsh and improving water quality in the famed herring run. The undeveloped triangular grass area within the watershed (Route 6A Triangle), was purchased with plans for implementation of stormwater structures to improve the current condition of the area.



In addition to Site No. 4, this grant provided funding to evaluate the Route 6A Triangle site (Site No. 2) for an innovative low impact development (LID) technique, specifically a constructed wetland or bio-filter within the vicinity of the triangular Town-owned parcel.

At the Paines Creek Road North of the Route 6A intersection, untreated runoff enters directly into Paines Creek at a small paved boat launch in addition to a paved scupper that directs untreated runoff into the wetland that abuts Wing Island. The drainage area has no catch basins or drainage structures of any type.

The long term goal of this project (once implemented) is to continue the improvements to the untreated stormwater discharges which continue to pollute and impact the overall water quality of the Stony Brook Watershed in order to open up closed shellfish areas in Paines Creek (CCB22:Stony Brook); protect open shellfish areas in the Brewster North Coastal shellfish growing area (CCB20); improve anadromous fish, rare species and salt marsh habitat; improve water quality at public bathing beaches; and improve the impacted headwaters of Stony Brook (i.e., Walkers Pond, Upper Mill Pond and Lower Mill Pond).

1.2 Project Partners

Project Partners include:

MassDEP ARRA Project Coordinator

Town of Brewster, Massachusetts

GHD Inc., Town's Engineering Consultant

1.3 Final Deliverables

The Tasks identified through this grant are as follows:

Task 1: Site Survey and Data Collection -

Deliverable 1: Submit detailed site plans suitable for completion of the design work in Task 2 for both sites.

Task 2: Preliminary Design Plans- 50% Review-

Deliverable 1: Compile existing drainage, impervious surface area, water quality, and infrastructure improvement plan information.

Deliverable 2: Submit preliminary design plans up to the 50% design level for DEP review and approval.

Deliverable 3: Meet with Town officials to discuss 50% design level plans.

Deliverable 4: Provide copies of Meeting Notes.

Task 3: Reports-

Deliverable 1: Monthly progress reports, monthly invoices including a P.V. Attachment for Reporting MBE/WBE Activity, quarterly progress and fiscal reports.

Deliverable 2: Draft and Final Report including final Town approved preliminary design plans.



2 Project Approach

2.1 Route 6A Triangle (Site No. 2)

As part of the CZM funded Paines Creek and Stony Brook Watershed Stormwater Mitigation Assessment developed in 2007, an initial concept design was developed showing a proposed planting plan and proposed grading plan. This design is included in Appendix A along with an engineer's estimate of \$235,000 of probable construction costs.

For this grant funded project, the next step was to gather needed information and records of the area, including the development of a topographic site plan. The site plan included a detailed property line survey, all utilities, buildings, landscaped features, and pertinent surficial features. Once this detailed survey was complete, design concepts began to be developed for this site. Soils information and groundwater depth was collected from a test pit performed as part of the Paines Creek and Stony Brook Watershed Stormwater Assessment on May 10, 2007 where soils were classified as loamy sand and groundwater was encountered at 41 inches.

The overall purpose of the design is to use the triangular site as a means of effective stormwater treatment by constructing a wetland type, naturalistically functioning, stormwater runoff renovation ecosystem with native plantings. Runoff renovation will be achieved through the use of multiple pathways for the runoff water that include drain inlets with sumps for heavy sediment dropout, collection and pooling of runoff in shallow and deep water pools and passage of runoff through dense plant growth. These systems have been designed to maintain an extended flow path from points of runoff entrance to the pond/wetland from the piped collection points to the point of outlet from the system into the natural receiving coastal waters.

Initially four design concepts were developed by a certified wetlands scientist and landscape architect and are identified below with a brief description of what components each concept design includes including draft cost estimates are attached in Appendix B. Stormwater managements systems are most often established as functioning engineered systems with minimal regard for a strong aesthetic component. However, the Brewster triangular site is positioned in a highly visible location with views into the site from the surrounding roadways and is a valuable visual element along the historic Route 6A corridor in Brewster. As such the design team thought that consideration of the visual character of the stormwater management system was equally as important as the desired runoff renovation elements. Therefore, four concept studies of how the stormwater management components might be configured within a desirable visual framework were made and presented to the stakeholders.

2.1.1 Concept #1 - Bubbles in a Pond

This concept design configured the stormwater management system to be primarily a pond/wetland habitat with deep and shallow water zones. Upland and transitional fringe zones along the bordering roadway edges were narrow. A series of round islands were incorporated within the design to help direct and control the follow path from the inlets to the outlet and to provide visual impact with their cluster of plantings emerging from the water. The runoff flow path was from points of collection into the pond/wetland edges and then through the water and plant zones for an extended length to the point of outlet. Pollutant removal and runoff renovation occurred through an extended stay time, sediment settlement in the still water, and biological and biochemical actions within the plant community and soils in



the system bottom. Deep and shallow water plantings were proposed along with native grasses and wildflowers with areas of deciduous and evergreen native trees adjacent to the open water system.

The visual aesthetic of the system was the expanse of open water dotted with the diversity of planted islands and the framing effect of the bordering evergreen and deciduous trees and shrubs.

2.1.2 Concept #2 - Naturalistically Undulating

This concept design configured the stormwater management with a central pond/wetland habitat that created an amoeba-like pattern on the site bordered by an expanded transitional and upland fringe zone. The runoff flow path was from points of collection into the pond/wetland edges and then through the undulating water and plant zones for an extended length to the point of outlet. Pollutant removal and runoff renovation occurred through an extended stay time, sediment settlement in the still water, and biological and biochemical actions within the plant community and soils in the system bottom. Deep and shallow water plantings were proposed along with native grasses and wildflowers and expanded plantings of deciduous and evergreen native trees adjacent in the transitional and upland areas.

The visual aesthetic of the system was the creation of what might appear to a viewer from the adjacent roadways of a natural waterway with scoured areas of deeper water set within an overgrowing field and young woodland habitat of native evergreen and deciduous trees and shrubs.

2.1.3 Concept #3 - Sharp Ridges and Wet Pools

This concept design configured the stormwater management with a physical structure somewhat between Concepts #1 and #2. However, rather than being naturalistic in character the land forms were developed as distinctly man made features with slopes with sharp edges and with steeper areas lined with stone rip rap. The runoff flow path was from points of collection into distinct entrance shallow water pool areas where the piped runoff would slow and enable sediments to drop out and then into a larger pond/wetland area. Within the larger open water and wetland system the open water and plant zones would slow the runoff flow for an extended length of time before the water reached the point of outlet. Pollutant removal and runoff renovation occurred through an extended stay time, sediment settlement in the still water, and biological and biochemical actions within the plant community and soils in the system bottom. Deep and shallow water plantings were proposed along with significant fringe area for transitional and upland plant growth of native grasses and wildflowers and plantings of deciduous and evergreen native trees set in clusters and as individuals.

The visual aesthetic of the system was the creation of what might appear to a viewer from the adjacent roadways of a dynamic water oriented and man-made land form with areas of deeper water set within an overgrowing field and planted tree habitat of native evergreen and deciduous trees and shrubs.

2.1.4 Concept #4- Old Bog Channels

This concept design configured the stormwater management with a landform structure reflecting the general visual character of Cape Cod and southern Massachusetts cranberry bogs. The landscape was sculpted as a series of flat plateaus divided by interconnected rectangular shaped channels. The runoff flow path was from points of collection into distinctly formed shallow water entrance pool areas where the piped runoff would slow and enable heavier sediments to drop out. From these pools the water would flow through the vegetated channels. Plant growth in these channels would restrict rapid water movement in the channels causing the runoff water to flow the channels and overflow the flat plateau areas during



heavier storm events. Runoff renovation would occur through physical settlement of sediments and biological and biochemical actions within the vegetative community and underlying soil strata of the channels. Shallow water flow across the plateaus would foster pollutant removal and renovation through sediment settlement within the detritus layer of the plant growth, and through biological and biochemical actions in the plant community. The plateaus were designed to be constructed at varied elevations to control timing of flooding and overflow and to create ecological conditions suitable for the growth of different plant species. The plateaus were designed to be planted with blocks of shrubs, evergreens, and deciduous trees tolerant of the different water regimes. The areas bordering the bog zone replication were proposed to be planted with a hedgerow type habitat that might have been associated with the created former land use.

The visual aesthetic of the system was the creation of what might appear to a viewer from the adjacent roadways of an overgrowing former cranberry bog but one that displayed distinct man influenced effects within the blocks of different vegetation on the plateaus.

In an effort to develop conceptual designs that were within the originally estimated \$235,000 budget; two additional concept designs were developed as follows.

2.1.5 Concept #5- Naturalistically Undulating 2

This concept design was configured following a meeting with stakeholders and represents a similar plan but one with reduced potential costs than Concept #2. The area of open water has been reduced lowering the volume of required excavation to create the ecosystem. Sediment trapping water pools remain at the runoff entrance points to the site. Extended runoff flow paths are enhanced from the original plan and remain through open water pools and shallow water wetland vegetation. The transitional and upland areas of the plan are delineated with groupings of evergreen trees and individual and clusters of deciduous trees. No mow grasses with wildflower overseeding are proposed for use as the primary ground surface plantings.

The visual aesthetic of the plan was the creation of what might appear to a viewer from the adjacent roadways of an overgrowing meadow habitat with individual trees and evergreen thickets surrounding a watercourse corridor with areas of open water.

2.1.6 Concept #6- Angles, Channels and Pools

This concept design was configured following a meeting with stakeholders and represents a plan that displays a simplified combination of Concepts #3 and #4. Runoff renovation flow paths have been enhanced from the earlier design and include shallow water sediment trapping pools at runoff entrances to the site, narrow vegetated channels leading to additional water pool areas, and a water pool zone at the runoff discharge from the site. Runoff flowing through the site will be renovated through sediment settlement and biological and biochemical actions in the wetland oriented plant community. Borders of and channels and wall pool are proposed to be shaped with man made slopes to the upland areas bordering the adjacent roadways and planted to a grove of evergreen trees and individual and small clusters deciduous trees and evergreens.

The visual aesthetic of the plan was the creation of what might to be a structured, man made landform with a watercourse system softened visually by the planting of meadow habitat and tree growth.



2.1.7 Design Concept Meeting

On May 14, 2010 a design concept meeting was held with Town personnel and board members as follows:

- >- Town Administrator
- >- Conservation Department Administrator
- >- Natural Resources & Shellfish Department Director
- >- Town Planner
- >- Brewster Conservation Trust
- >- Open Space and Planning Board
- >- Brewster Mill Sites/Alewife Committee

The purpose of this meeting was to get Town approval of a concept so as to develop this concept further into a 50% design. After this meeting it was determined that a natural appearance was best for the area and Concept #5, "Naturalistically Undulating 2" was selected for further design as part of this grant. At the request of the Town, an informational presentation to the Board of Selectmen was made on June 21, 2010 to go over the concept for this parcel and to provide examples of previous projects where constructed wetlands were built. The handout provided to the Board of Selectmen is included in Appendix C.

2.2 Paines Creek Road North of the Route 6A Intersection (Site No. 4)

As part of the CZM funded Paines Creek and Stony Brook Watershed Stormwater Mitigation Assessment developed in 2007, an initial concept design was developed. This design is included in Appendix A along with an engineer's estimate of \$55,000 of probable construction costs.

For this grant funded project, the Paines Creek North of Rt. 6A site base plan is Geographic Information System (GIS) based and existing conditions data was developed from a combination of GIS (Massachusetts and Brewster data) and USGS topographical maps and site evaluations. There are no existing utilities or infrastructure within this area except for a culvert located outside of the design limits. The final design will collect and infiltrate the first flush of stormwater, which has the highest concentration of pollutants so that runoff will not enter Paines Creek.

3 Results

3.1 50% Design Results

The preliminary design plans titled "Town of Brewster, MA, Paines Creek and Stony Brook Watershed Stormwater Mitigation Project, Contract No. 2009-03/ARRA 604" are attached in Appendix D. Sheet C001 is the site plan for the Paines Creek Road – North site which includes two catch basins which will collect the stormwater runoff. The catch basins are connected to a settling tank which is a baffled precast structure which will allow for sediments to settle prior to flowing into the infiltration field. The infiltration field consists of 16 low-profile infiltration chambers. Sheet COOS provides miscellaneous notes and details. This drainage system will provide pre-treatment to the stormwater instead of direct runoff from the paved surface. MassDEP credits subsurface recharge systems with 80% removal of Total Suspended



Solids (TSS), although other literature provides estimates of 90% or greater. There is minimal information on pathogens/bacteria and nutrient removal via subsurface recharge systems.

It is expected that the removal rate can be assumed at 80% because the majority of the stormwater runoff including pathogens/bacteria and nutrients will not reach the surface waters directly. Removal quantities below are derived from the Watershed-Based Plan for the Cape Cod Basin – Monomoy Groundwater Flow Cell and Structural BMPs -Volume 2 of the Massachusetts Stormwater Handbook. The reader is directed to Appendix E for more detailed calculations and excerpts.

TSS Removed	Fecal Coliform Removed	TP Removed	TN Removed
259 lbs/year	8.09 x 10 ¹⁰ counts/year	61bs/year	76 1bs/year

The targeted pollutants are suspended solids, pathogens/bacteria and nutrients. The settling tank allows solids to settle out of the runoff prior to being infiltrated into the groundwater. It is expected that pathogens/bacteria will be significantly reduced by means of settling solids and infiltrating the majority of the runoff.

To the extent practicable as a redevelopment project, the designed BMPs were developed in accordance with the Massachusetts Stormwater Handbook to handle the first flush of runoff. The field of 16 shallow infiltrator units is adequate to handle 10-year storm events based on storage and minimal leaching of the receiving soils (0.05 gpm/sf).

Sheet C002 through C004 include the Route 6A Triangle site plan and details, plantings plan and graphic site sections. Following the selection of a desired concept approach by the stakeholders a preliminary site design was developed and delineated using the Concept #5 plan as its prototype. Locations for the installation of drain inlets for the collection of runoff from the watershed were identified and established. Based upon these a grading plan was developed for installing piping under roadways to direct the collected runoff into the site's stormwater management ecosystem. The existing elevations in the watershed dictated how details of the selected site design would be implemented. These elevations established elevations for the runoff entry water pools and associated wetland habitat areas shaped for the transporting of the runoff water through vegetation communities to the point of discharge from the site. Watershed collection point elevations and the resulting site grades dictated a need to reevaluate the points of runoff drainage into and from the site to meet the required elevations. The required elevations dictated that the point of discharge from the site had to be relocated from that originally considered in the concept designs. However, the basic tenants of the original concept design for extended pathways and stay time in the system were maintained. Once grading for the stormwater management basin was established, grading requirements for the surrounding transitional and upland areas to the adjacent roadways were developed. Working with project budget limitations, a series of mounds were created surrounding the lower level basin in order to minimize potential anticipated costs for the transport of excavated material from the site. A preliminary planting plan was also delineated and detailed cross sections through the site in two directions were drawn. Basic details for stormwater management structures were drawn using planning practices that focused toward presenting simple, long term use and easily maintained site elements. The 50% constructed wetland design was developed in accordance with the Massachusetts



Stormwater Handbook to handle the first inch of runoff from the entire watershed area including pervious and impervious areas.

It is expected that the TSS removal rate can be assumed at 80% because the majority of the stormwater runoff including pathogens/bacteria and nutrients will not reach the surface waters directly. In addition, constructed stormwater wetlands also reduce total nitrogen from 20% to 55%, total phosphorus from 40% to 60%, metals 20% to 85% and pathogens up to 75% according to the pollutant removal efficiencies information for constructed stormwater wetlands from the Massachusetts Stormwater Handbook (see excerpt in Appendix E). Removal quantities below are derived from the Watershed-Based Plan for the Cape Cod Basin – Monomoy Groundwater Flow Cell and Structural BMPs – Volume 2 of the Massachusetts Stormwater Handbook. The reader is directed to Appendix E for more detailed calculations and excerpts.

TSS Removed	Fecal Coliform Removed	TP Removed	TN Removed
469 lbs/year	1.37×10^7 counts/year	5-8 lbs/year	68-103 lbs/year

3.2 Lessons Learned

For the Paines Creek Road North of the Route 6A Intersection site; the infrastructure moved from along side of the road as depicted in the initial concept design developed as a result of the 2007 CZM Stormwater Assessment (see Appendix A) to within the road for greater stability as a result of this project's funding (see Appendix D). For the Route 6A Triangle site, the series of conceptual designs created for an area that borders a scenic, historic highway provided an opportunity to expand the technical requirements for stormwater runoff to include consideration of visual, aesthetic features.

4 Conclusions/Project Summary

The overall outcome of this project is successful in terms of design. The Paines Creek Road North of the Route 6A Intersection (Site No. 4) was submitted to the United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) Cape Cod Water Resources Restoration Project for grant money to complete the final design of this area and construction of stormwater improvements. This area was selected by the NRCS and will be remediated during 2011. The probable construction costs for this area within the limits of the 50% design are estimated to be \$55,000 as included in Appendix A.

The Route 6A Triangle site (Site No. 2) now has a delineated preliminary site plan which represents a functioning stormwater management system that displays a naturalistic aesthetic component and incorporates a potentially accessible landform for an area of the community adjacent to coastal wetlands. The probable construction costs for this area within the limits of the 50% design are estimated to be \$235,000 as included in Appendix A. This plan provides opportunity for public access and the installation of signage informing visitors about the importance of stormwater management for the health of Cape Cod's coastal ecosystems.



Permitting issues were not addressed in this report for either site and will need to be addressed in the final design phase.

5 Literature Cited

Paines Creek and Stony Brook Watershed Stormwater Mitigation Assessment, Assessment Report, June 2007, Stearns & Wheler, LLC for the Town of Brewster, Massachusetts

Technical Memorandum, Watershed-Based Plan for the Cape Cod Basin, September 2006, Prepared by Beta Group, Inc., Applied Technology & Management, Inc. and Baystate Environmental Consultants, Inc. for the Massachusetts Department of Environmental Protection, Worcester, Massachusetts.

Massachusetts Stormwater Handbook, Volumes 1 through 3, Massachusetts Department of Environmental Protection, February 2008.

6 Appendices

Appendix A: Paines Creek and Stony Brook Stormwater Assessment Report, Preliminary Designs and Draft Cost Estimates

Appendix B: Design Concepts, Engineer's Estimates of Costs, and May 14, 2010 Meeting Minutes

Appendix C: Board of Selectmen Presentation of Project, June 21, 2010

Appendix D: 50% Design Plans, Paines Creek and Stony Brook Watershed Stormwater Mitigation Project, January, 2011

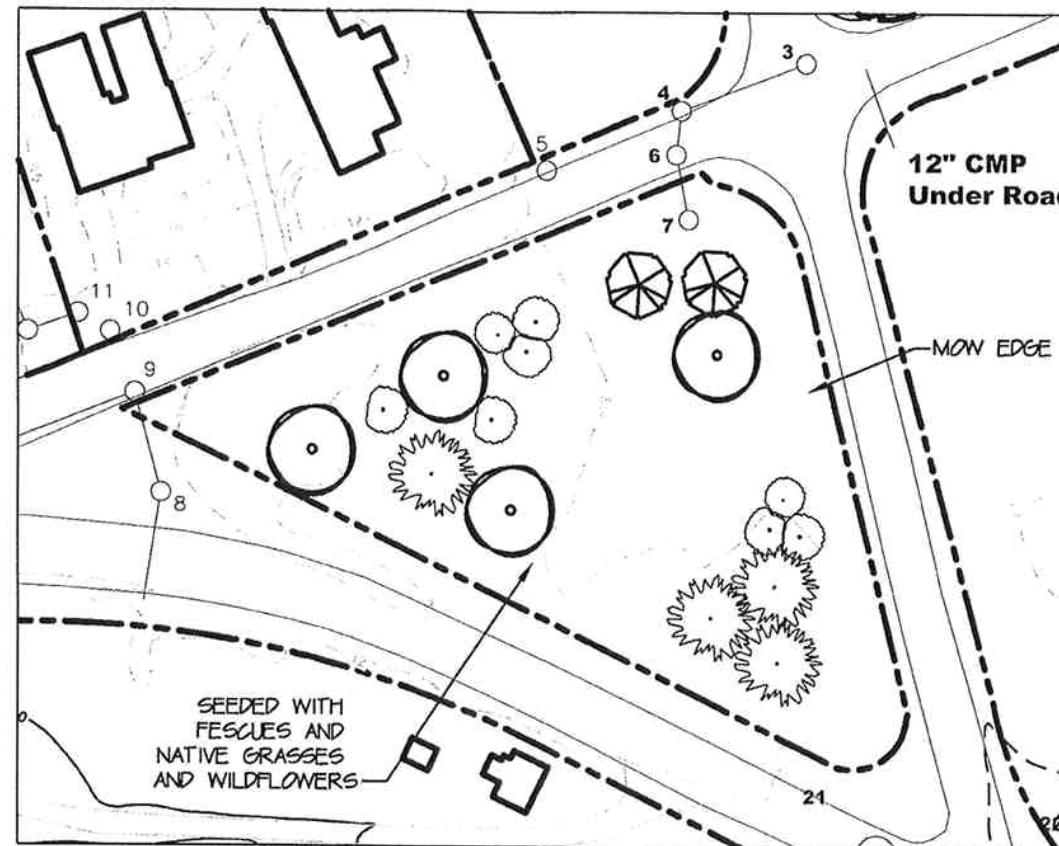
Appendix E: Pollutant Removal Quantities and Calculations Watershed-

Based Plan for the Cape Cod Basin Excerpts

Volume 2 Chapter 2: Structural BMP Specifications for the Massachusetts Stormwater Handbook

Appendix A





Paines Creek and Stony Brook Stormwater Assessment Report, Preliminary Designs and Draft Cost Estimates

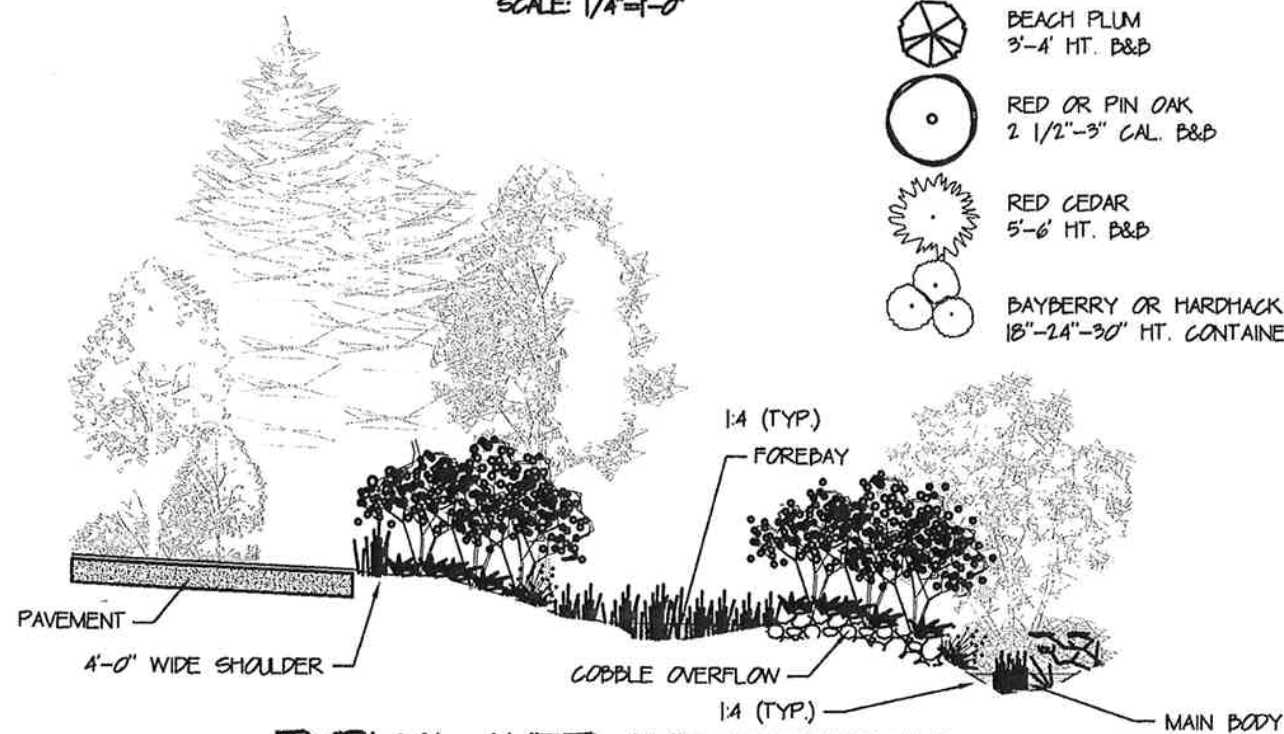


PROPOSED PLANTING PLAN

SCALE: 1/4"=1'-0"

PLANTING LEGEND

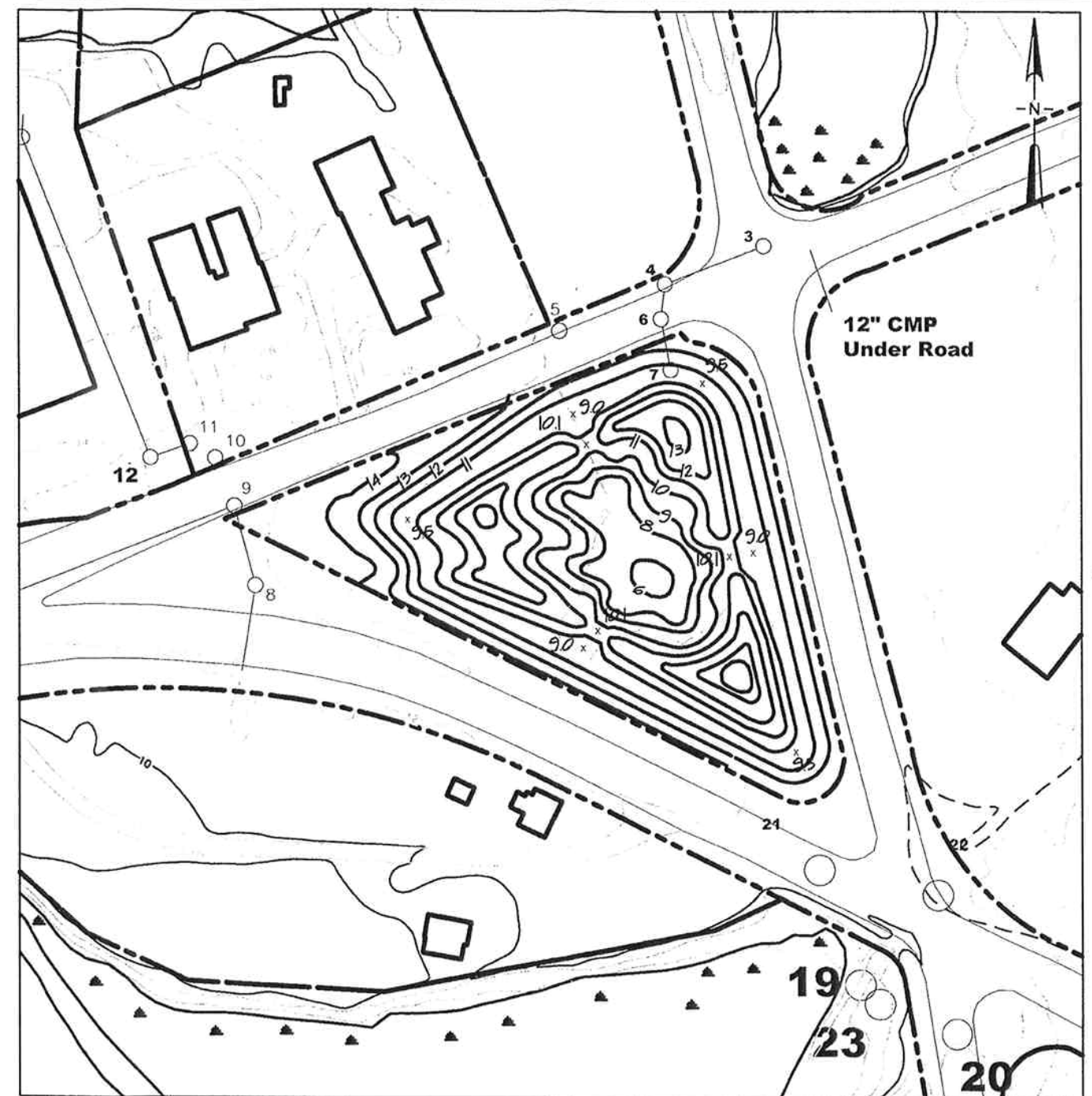
-  BEACH PLUM
3'-4' HT. B&B
-  RED OR PIN OAK
2 1/2"-3" CAL. B&B
-  RED CEDAR
5'-6' HT. B&B
-  BAYBERRY OR HARDHACK
18"-24"-30" HT. CONTAINER



TYPICAL WETLAND FOREBAY CROSS SECTION

SCALE: 1/4"=1'-0"

NOTE: FOREBAY SECTION SHOWING VEGETATION ASSOCIATIONS AND GROWTH PATTERNS, DETAIL PROPORTIONAL BUT NOT TO SCALE.



PROPOSED GRADING PLAN

SCALE: 1/4"=1'-0"



Stearns & Wheeler, LLC
Environmental Engineers and Scientists

HYANNIS, MA

DATE: 6/26/07 JOB No.: 71080

STONEY BROOK WATERSHED ASSESSMENT
TOWN OF BREWSTER, MASSACHUSETTS
APPENDIX E

FIGURE 2
ROUTE 6A TRIANGLE

Login name: RHK
Filename path: J:\70000\71080\10\Drawings\Fig
Filename: Site Plan.dwg
Latest Revision: Tuesday, June 26, 2007

ENGINEERS ESTIMATE OF PROBABLE CONSTRUCTION COSTS

Conceptual Designs of Priority Stormwater Improvement Sites

Stony Brook Watershed Assessment

Town of Brewster, MA

S&W Project No. 71080

Site 2 - Route 6A		Estimated	Unit of	Unit Cost	Total
		Quantity	Measure		
<u>Unit Price</u>					
1	Beach Plum	2	EA	\$500	\$1,000
2	Red Oak	3	EA	\$750	\$2,000
3	Red Cedar	4	EA	\$1,000	\$4,000
4	Bayberry	8	EA	\$500	\$4,000
5	Sand Material for Wetland Subbase	5,000	CY	\$18	\$90,000
<u>Lum Sum</u>					
6	Mobilization, Demobilization and Miscellaneous	1	LS	\$10,100	\$10,000
7	Earthwork, Shaping and Grading	1	LS	\$85,000	\$85,000
8	Site Restoration	1	LS	\$7,500	\$8,000
9	Record Drawings	1	LS	\$2,500	\$3,000

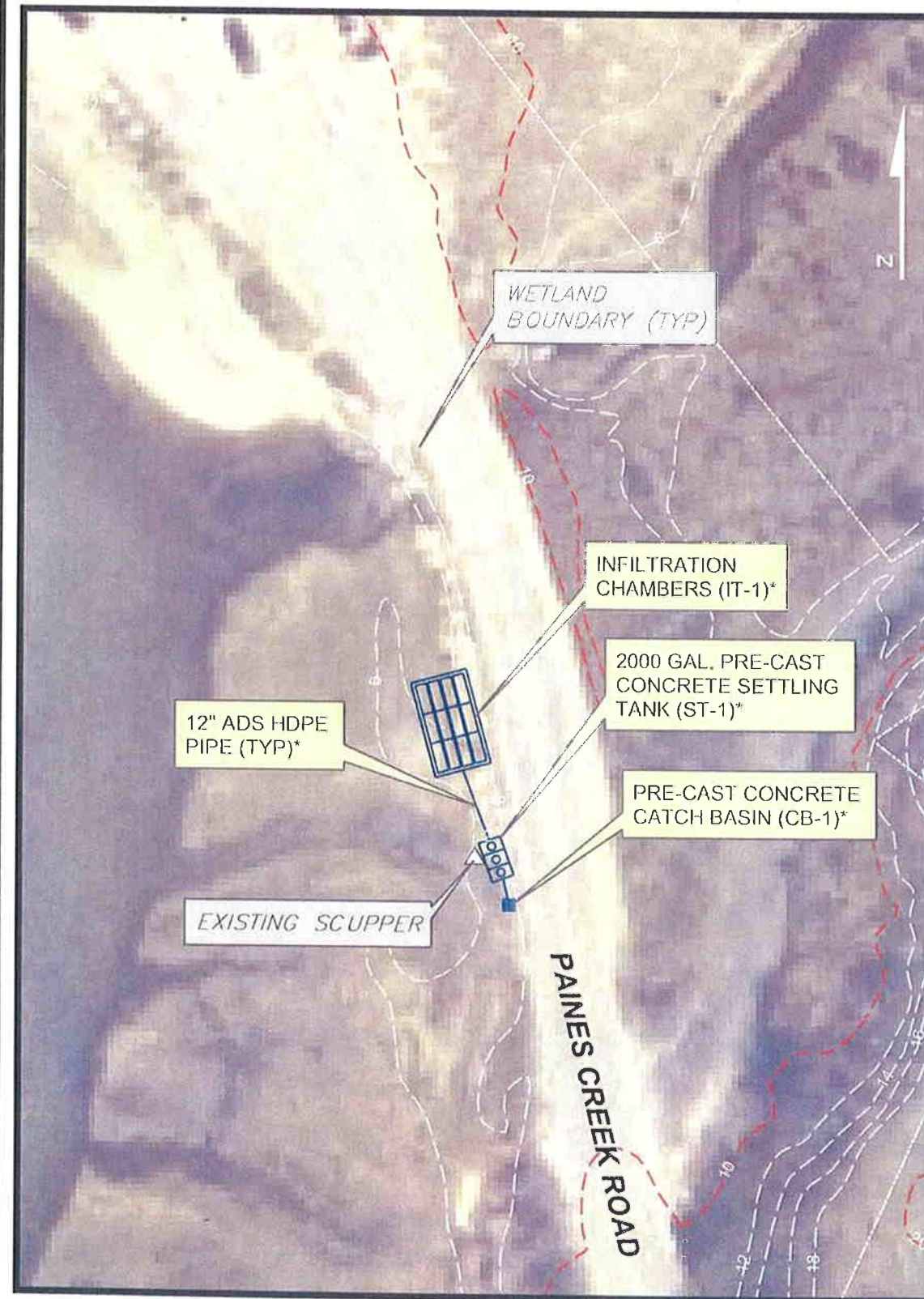
Construction Cost Subtotal: \$ 204,000

..

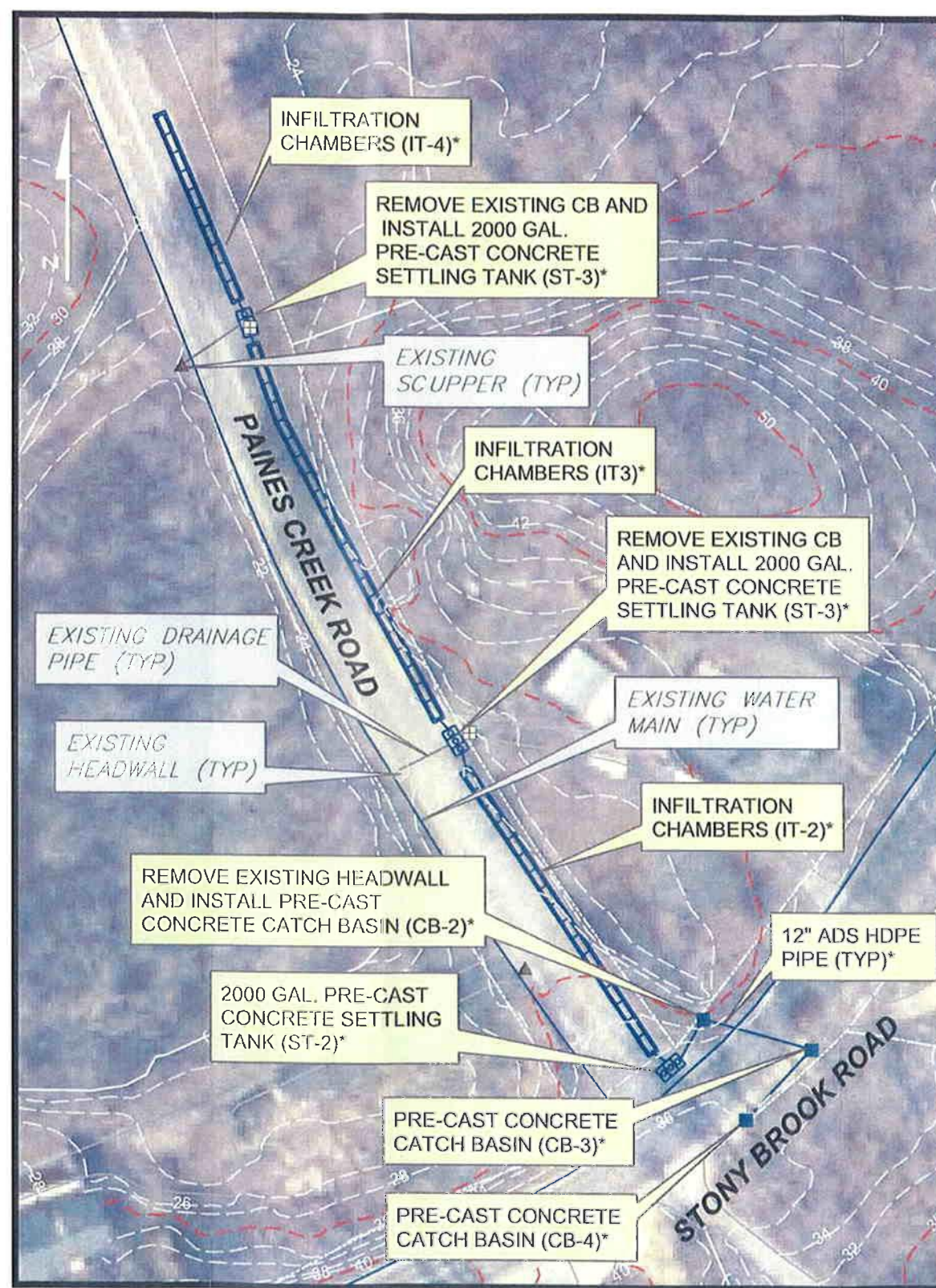
Contingency (10%): \$ 20,400

Fiscal/Legal/Administration (5%): \$ 10,200

Estimated Project Cost \$ 235,000



PLAN - Paines Creek Road North of 6A
Scale 1" = 40'-0"



PLAN - Paines Creek Road South of 6A
Scale 1" = 60'-0"

INVERT SCHEDULE - PAINES CREEK NORTH

CB-1 RIM ELEVATION: MATCH EXISTING GRADE
CB-1 INV OUT TO ST-1:

ST-1 RIM ELEVATION: MATCH EXISTING GRADE
ST-1 IN FROM CB-1:
ST-1 INV OUT TO IT-1:

INFILTRATION TRENCH (IT-1)
RIM ELEVATION (ALL): MATCH EXISTING
INV. IN FROM ST-1:

INVERT SCHEDULE - PAINES CREEK SOUTH

CATCH BASIN (CB)
CB-2 RIM ELEVATION: 30.00
CB-2 INV IN FROM CB-3: 30.05
CB-2 INV OUT TO ST-2: 29.00

CB-3 RIM ELEVATION: EXISTING GRADE
CB-3 INV IN FROM CB-4: 30.5
CB-3 INV OUT TO ST-2: 29.2

CB-4 RIM ELEVATION: EXISTING GRADE
CB-4 INV OUT TO CB-3: 31.00

SETTLING TANK (ST)
ST-2 RIM ELEVATION: MATCH EXISTING GRADE
ST-2 IN FROM CB-1: 28.9
ST-2 INV OUT TO IT-2: 28.7

ST-3 RIM ELEVATION: MATCH EXISTING GRADE
ST-3 IN FROM IT-2: 22.5
ST-3 INV OUT TO IT-3: 22.0
ST-3 INV OUT TO EX PIPE

ST-4 RIM ELEVATION: MATCH EXISTING GRADE
ST-4 IN FROM CB-1: 22.00
ST-4 INV OUT TO IT-4: 22.00

INFILTRATION TRENCH (IT)
(IT-2) RIM ELEVATION (ALL): MATCH EXISTING
(IT-2) INV. IN FROM ST-2: 28.6
(IT-2) INV. OUT TO ST-3: 22.5

(IT-3) RIM ELEVATION (ALL): MATCH EXISTING
(IT-3) INV. IN FROM ST-3: 21.9
(IT-3) INV. OUT TO ST-4: 21.9

(IT-4) RIM ELEVATION (ALL): MATCH EXISTING
(IT-4) INV. IN FROM ST-4: 21.9



Stearns & Wheeler, LLC
Environmental Engineers and Scientists

HYANNIS, MASSACHUSETTS

Date: 05/30/07

Town of Brewster, Massachusetts
Stony Brook Watershed Assessment

Paines Creek Road North of 6A -
Paines Creek Road South of 6A

Appendix E - Figure 3

ENGINEERS ESTIMATE OF PROBABLE CONSTRUCTION COSTS

Conceptual Designs of Priority Stormwater Improvement Sites

Stony Brook Watershed Assessment

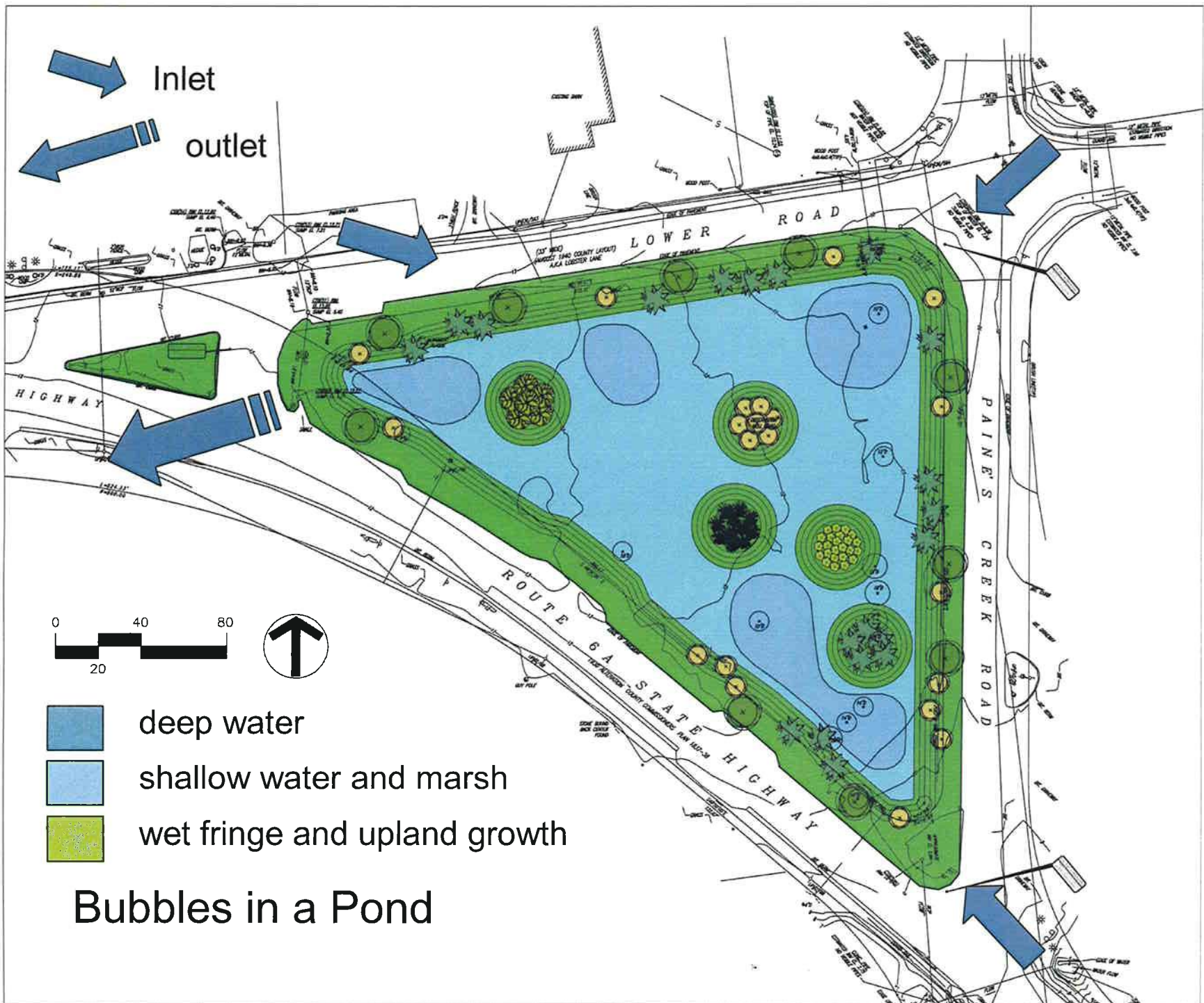
Town of Brewster, MA

S&W Project No. 71080

Site 3- Paines Creek Road North of Route 6A		Estimated	Unit of	Unit Cost	Total
		Quantity	Measure		
<u>Unit Price</u>					
1	Settling Tank	1	EA	\$6,500	\$6,500
2	Leaching Pit	1	EA	\$4,000	\$4,000
3	Flow Control Structure	0	EA	\$6,000	\$0
4	Catch Basin	1	EA	\$3,000	\$3,000
5	Infiltrator	16	EA	\$850	\$13,600
6	Storm Sewer Piping	0	LF	\$50	\$0
7	Surface Restoration	200	SY	\$48	\$9,600
8	Police Detail	40	HR	\$50	\$2,000
<u>Lum! Sum</u>					
9	Mobilization, Demobilization and Miscellaneous	1	LS	\$6,275	\$6,300
10	Site Restoration	1	LS	\$2,500	\$2,500
11	Record Drawings	1	LS	\$2,500	\$2,500
					..
Construction Cost Subtotal:					\$ 48,000
Contingency (10%) :					\$ 4,800
Fiscal!LegaVAdministration (5%):					\$ 2,400
Estimated Project Cost					\$ 55,000

Appendix B

Design Concepts
Engineer's Estimates of Costs
May 14, 2010 Meeting Minutes"



Brewster Massachusetts, Stormwater Management Plan

Concept #1: Bubbles in a Pond

DRAFT Cost Estimate

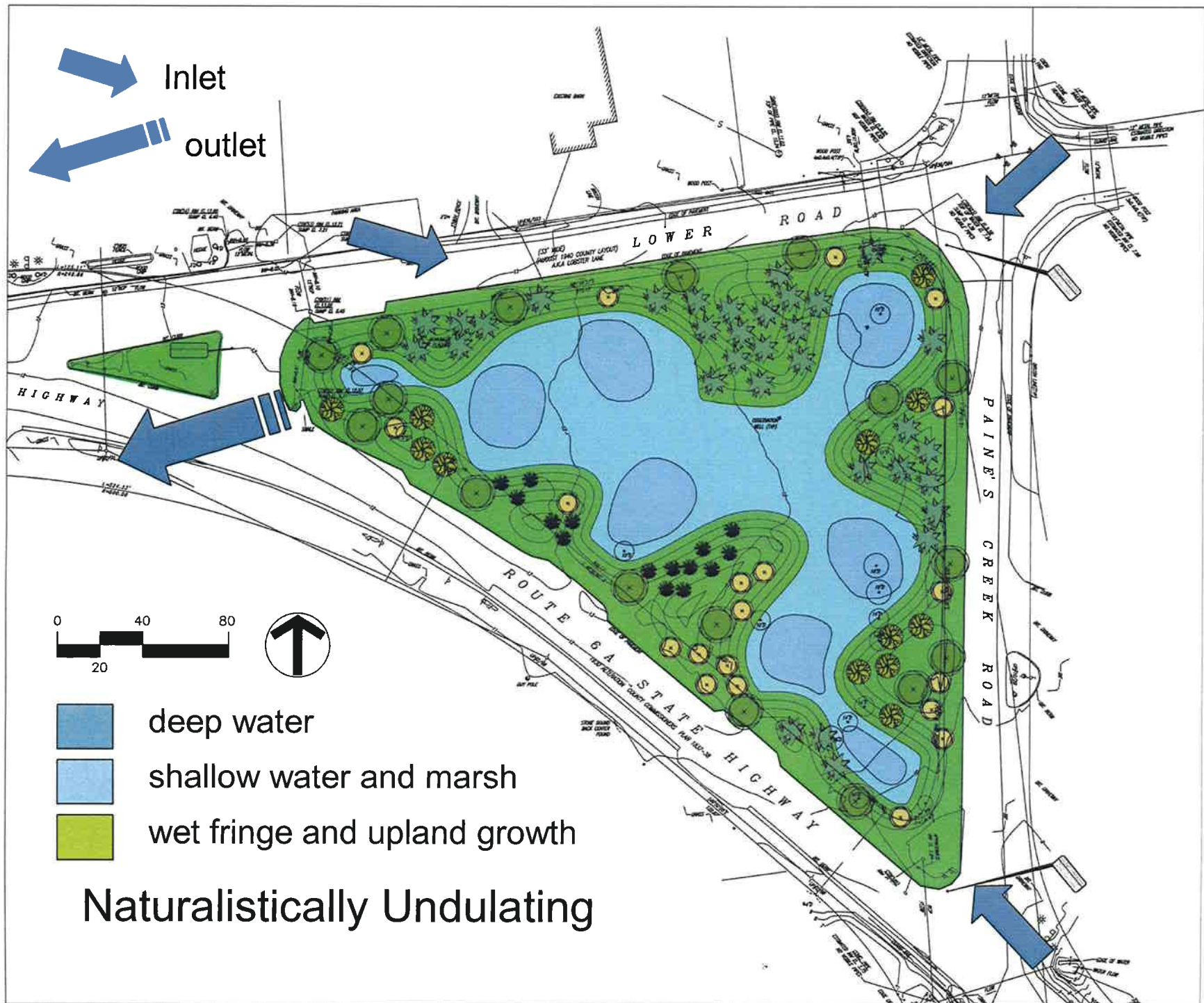
Project Phase: Concept Design

Based on Plans Dated: May 2010

Date Estimate Prepared: 10 May 2010

Prepared By: Farlow

Stormwater Management and Utilities				
Item #	Description	Qty	Unit	Unit Installed Cost
	drain inlets	8	ea	\$3,000.00
	stormwater piping	1050	lf	\$50.00
	inlet headwalls	3	ea	\$1,500.00
	outlet structure	1	ea	\$5,000.00
	drain inlet retrofit	2		\$2,500.00
	site utilities- coordination	1	ls	\$2,500.00
Stormwater Management and Utilities Subtotal:				\$ 93,500.00
Earthwork, Subgrade Preparation				
Item #	Description	Qty	Unit	Unit Installed Cost
	land clearing	10	ea	\$2,000.00
	topsoil strip and stockpile	2000	cy	\$
	earth excavation	13250	cy	\$ 10.00
	haul material from site	13000	cy	\$
	rough grading	2500	sf	\$
	topsoil spread and finish grade	2000	cy	\$ 10.00
Earthwork, Subgrade Preparation Subtotal:				\$ 154,500.00
Site Features and Furnishings				
Item #	Description	Qty	Unit	Unit Installed Cost
	road restoration paving	1500	sy	\$ 25.00
	painting Lines	200	lf	\$ 2.00
Site Features and Furnishings Subtotal:				\$ 37,900.00
Plantings				
Item #	Description	Qty	Inflation Factor (2.0, 2.5, etc.)	Purchase Cost
	major trees	23	2.5	\$ 27500
	minor trees	14	2.5	\$ 180.00
	shrubs	24	2.5	\$ 24.00
	evergreens	32	2.5	\$ 150.00
	aquatic species	250	1	\$ 12.00
	upland fringe seeding - square feet	22000	1	\$ 0.20
	wetland mudflat seeding - square feet	20000	1	\$ 0.15
Site Plantings Subtotal:				\$ 46,000.00
Site Work Subtotal:				\$ 331,900.00
Miscellaneous				
		Qty	Unit	Unit Installed Cost
	Mobilization	1	LS	\$5,000.00
	Erosion Control and Tree Protection	1	LS	\$10,000.00
	Site Clearing and Disposal			\$
	Site Grading			\$
	Site Stormwater Facilities			\$
	Site Electrical, Gas and Water Utilities			\$
	Traffic Control	160	HR	\$50.00
Miscellaneous Subtotal:				\$ 18,000.00
Project Totals				
Subtotal:				\$ 349,900.00
Contingency Percentage of				
Add Contingency:				\$ 34,990.00
Grand Total:				\$ 384,900.00



Brewster Massachusetts, Stormwater Management Plan

Concept #2: Naturalistically Undulating

DRAFT Cost Estimate

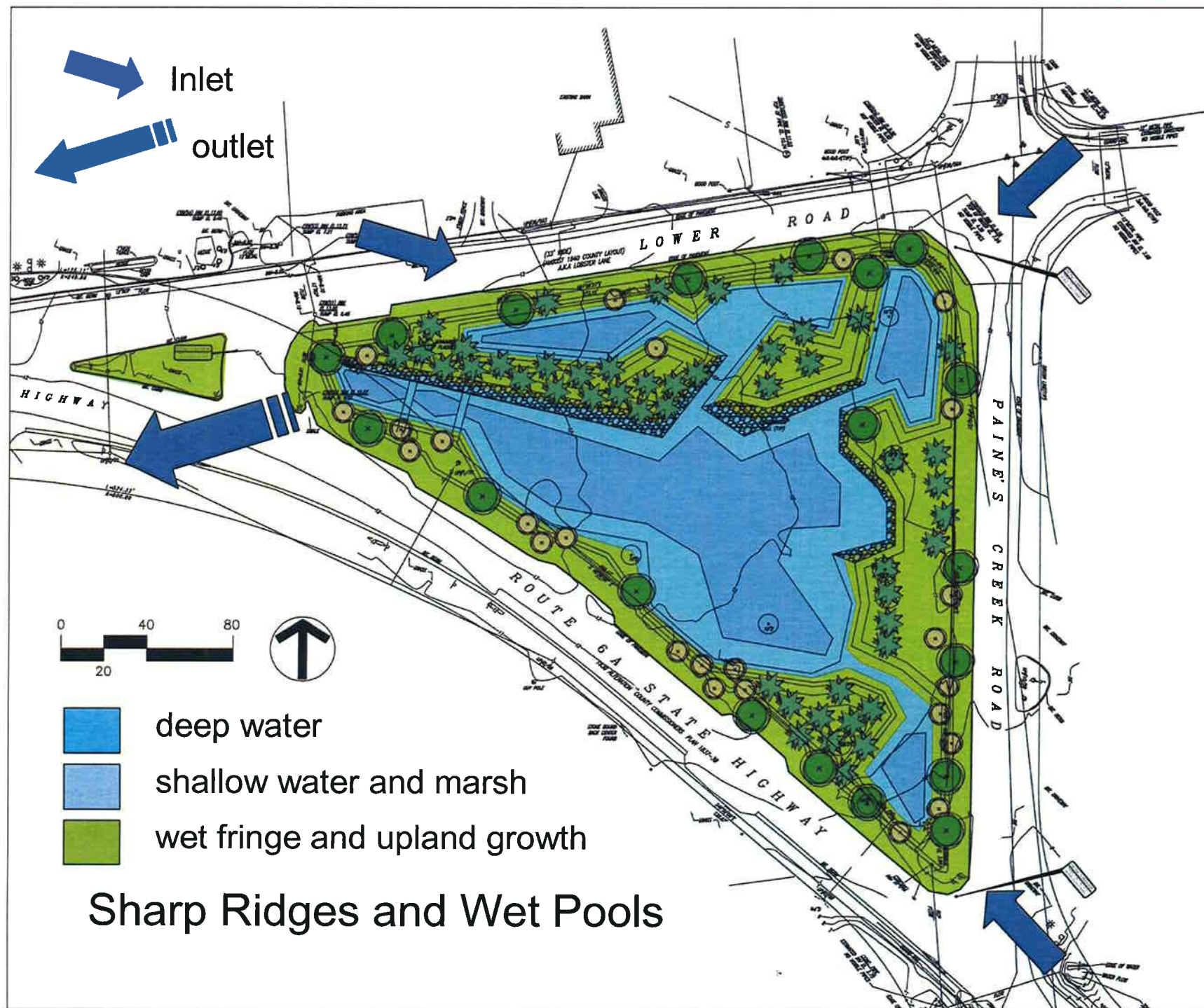
Project Phase: Concept Design

Based on Plans Dated: May 2010

Date Estimate Prepared: 10 May 2010

Prepared By: Farlow

Stormwater Manaaement and Utilities				
Item #	Description	Qty.	Unit	Unit Installed Cost
	drain inlets	8	ea	\$3,000.00
	stormwater piping	1050	lf	\$5000
	inlet headwalls	3	ea	\$1,500.00
	outlet structure	1	ea	\$5,000.00
	drain inlet retrofit	2		\$2,500.00
	site utilities- coordination	1	\$	\$2,500.00
Stormwater Management and Utilities Subtotal:				\$ 93,500.00
Earthwork, Subgrade Preparation				
Item #	Description	Qty.	Unit	Unit Installed Cost
	clearing	10	ea	\$ 200.00
	topsoil strip and stockpile	2000	cy	\$
	earth excavation	10500	cy	\$ 1000
	haul material from site	9000	cy	\$
	rough grading	4000	sy	\$
	topsoil spread and finish grade	2000	cy	\$ 1000
Earthwork Subgrade Preparation Subtotal:				\$ 127,000.00
Site Features and Furnishings				
Item #	Description	Qty.	Unit	Unit Installed Cost
	road restoration paving	1500	sy	\$ 2500
	Painted Unes	200	lf	\$ 200
Site Features and Furnishings Subtotal:				\$ 37,900.00
Plantings				
Item #	Description	Qty.	Installation Factor (2.0, 2.5, etc.)	Purchase Cost
	major trees	16	2.5	\$ 27500
	minor trees	12	2.5	\$ 18000
	shrubs	42	2.5	\$ 2400
	evergreens	33	2.5	\$ 15000
	aquatic species	250	1	\$ 1200
	pland fringe seeding -square feet	35600	1	\$ 0.20
	wetland mudHal seeding -square feet	12000	1	\$ 0.15
Site Plantings Subtotal:				\$ 43200.00
Site Work Subtotal:				\$ 301,600.00
Miscellaneous				
		Qty.	Unit	Unit Installed Cost
	Mobilization	1	LS	\$5,000.00
	Erosion Control and Tree Protection	1	LS	\$10,000.00
	Site Clearino and Disoosal			\$
	Site Gradino			\$
	Site Stormwater Facilities			\$
	Site Electrical, Gas and Water Uilities			\$
	Traffic Control	160	HR	\$50.00
Miscellaneous Subtotal:				\$ 18000.00
Project Totals				
Subtotal:				\$ 319,600.00
Contingency Percentage:				10%
Added Contingency :				\$ 31960.00
Grand Total:				\$ 351,600.00



Brewster Massachusetts, Stormwater Management Plan

Concept #4: Sharp Ridges and Wet Pools

DRAFT Cost Estimate

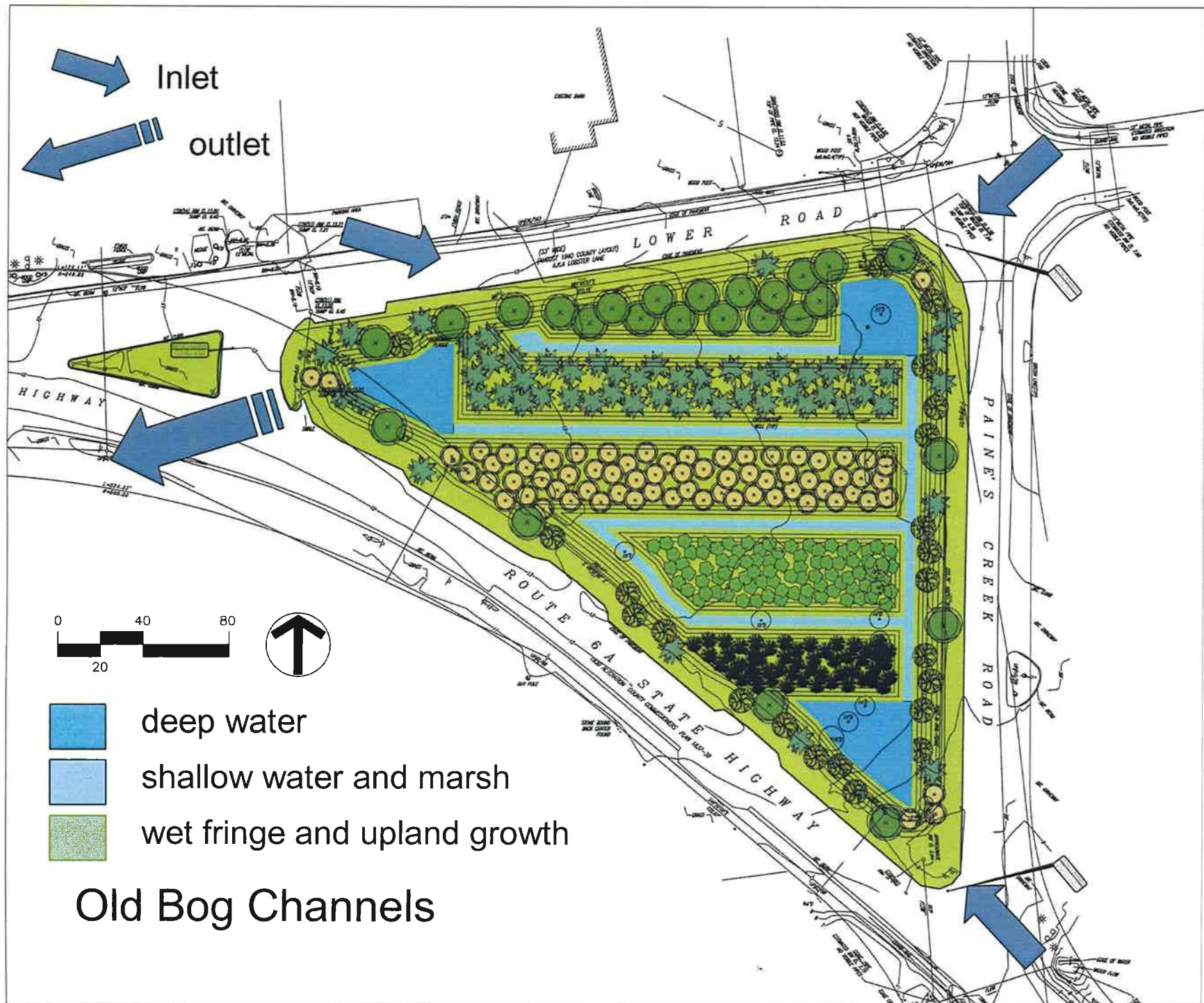
Project Phase: Concept Design

Based on Plans Dated: May 2010

Date Estimate Prepared: 10 May 2010

Prepared By: Farlow

Stormwater Management and Utilities					
Item #	Description	Qty	Unit	Unit Installed Cost	Total Cos
	drain inlets	8	ea	\$3000.00	\$ 24,000.00
	stormwater piping	1050	lf	\$5000	\$ 52,500.00
	inlet headwalls	3	ea	\$1,500.00	\$ 4,500.00
	outlet structure	1	ea	\$5,000.00	\$ 5,000.00
	drain inlet retrofit	2	ea	\$2,500.00	\$ 5,000.00
	site utilities- coordination	1	ls	\$2,500.00	\$ 2,500.00
Stormwater Management and Utilities Subtotal:					\$ 93,500.00
Earthwork, Subgrade Preparation					
Item #	Description	Qty	Unit	Unit Installed Cost	Total Cos
	clearing	10	ea	\$ 200.00	\$ 2,000.00
	topsoil strip and stockpile	2000	cy	\$	\$ -
	earth excavation	13300	cy	\$ 1000	\$ 133000.00
	haul material from site	12000	cy	\$	\$ -
	rough grading	5000	sy	\$	\$ -
	topsoil spread and finish grade	2000	cy	\$ 1000	\$ 20,000.00
Earthwork, Subgrade Preparation Subtotal:					\$ 155,000.00
Site Features and Furnishings					
Item #	Description	Qty	Unit	Unit Installed Cost	Total Cos
	road restoration paving	1500	sy	\$ 2500	\$ 37,500.00
	painted Lines	200	lf	\$ 200	\$ 400.00
	stone rip rap	400	cy	\$ 5000	\$ 20,000.00
Site Features and Furnishings Subtotal:					\$ 57,900.00
Plantings					
Item #	Description	Qty	Installation Factor (2.0, 2.5, etc.)	Purchase Cost	Total Cos
	major trees	14	2.5	\$ 27500	\$ 9,625.00
	minor trees	26	2.5	\$ 18000	\$ 11,700.00
	shrubs	30	2.5	\$ 2400	\$ 1,800.00
	evergreens	48	2.5	\$ 15000	\$ 18,000.00
	aquatic species	250	1	\$ 1200	\$ 3,000.00
	upland fringe seeding .square feet	31000	1	\$ 0.20	\$ 6,200.00
	wetland mudflat seeding .square feet	10000	1	\$ 0.15	\$ 1,500.00
Site Plantings Subtotal:					\$ 51,800.00
Site Work Subtotal:					\$ 358,200.00
Miscellaneous					
		Qty	Unit	Unit Installed Cost	Total Cos
	Mobilization	1	LS	\$5,000.00	\$ 5,000.00
	Erosion Control and Tree Protection	1	LS	\$10,000.00	\$ 10,000.00
	Site Clearing and Disposal				\$
	Site Grading				\$
	Site Stormwater Facilities				\$ -
	Site Electrical, Gas and Water Utilities				\$ -
	Traffic Control	160	HR	\$50.00	\$ 8,000.00
Miscellaneous Subtotal:					\$ 18,000.00
Project Totals					
Subtotal:				\$	376,200.00
Contingency Percentage?					10%
Added Contingency:				\$	37,620.00
Grand Total:				\$	413,800.00



Brewster Massachusetts, Stormwater Management Plan

Concept #5: Old Bog Channels

DRAFT Cost Estimate

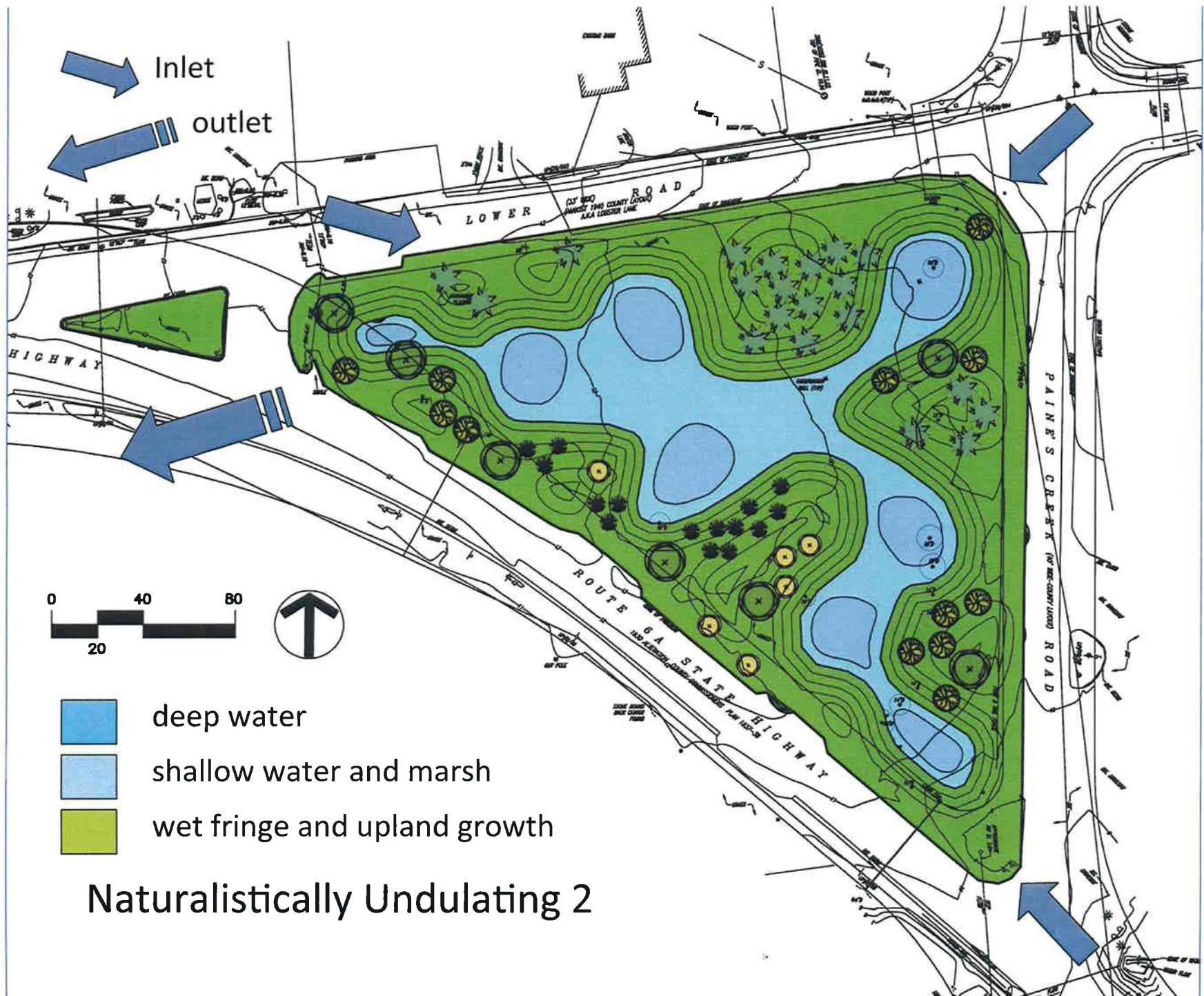
Project Phase: Concept Design

Based on Plans Dated: May 2010

Date Estimate Prepared: 10 May 2010

Prepared By: Farlow

Stormwater Management and Utilities				
Item #	Description	Qty	Unit	Unit Installed Cost
	drain inlets		Sea	\$3,000.00
	stormwater piping	1050	lf	\$50.00
	Inlet headwalls	3	ea	\$1,500.00
	outlet structure	1	ea	\$5,000.00
	drain inlet retrofit	2		\$2,500.00
	site utilities- coordination	1	IS	\$2,500.00
Stormwater Management and Utilities Subtotal				\$ 93,500.00
Earthwork, Subgrade Preparation				
Item #	Description	Qty	Unit	Unit Installed Cost
	clearing	10	ea	\$ 200.00
	topsoil strip and stockpile	2000	cuy	\$
	earth excavation	7020	cuy	\$ 1000
	haul material from site	6500	cuy	\$
	rough grading	4500	sy	\$
	topsoil spread and finish grade	2000	cv	\$ 1000
Earthwork, Subgrade Preparation Subtotal				\$ 92,200.00
Site Features and Furnishings				
Item #	Description	Qty	Unit	Unit Installed Cost
	road restoration paving	1500	sy	\$ 25.00
	painted Lines	200	lf	\$ 2.00
Site Features and Furnishings Subtotal				\$ 37,900.00
Plantings				
Item #	Description	Qty	Installation Factor (2.0, 2.5, etc.)	Purchase Cost
	major trees	24	2.5	\$ 275.00
	minor trees	63	2.5	\$ 15000
	shrubs	106	2.5	\$ 24.00
	evergreens	102	2.5	\$ 150.00
	aquatic species	100	1	\$ 12.00
	upland fringe seeding -square feet	40000	1	\$ 0.20
	wetland mudflat seeding -square feet	1000	1	\$ 0.15
Site Plantings Subtotal				\$ 101,600.00
Site Work Subtotal				\$ 325,200.00
Miscellaneous				
		Qty	Unit	Unit Installed Cost
	Mobilization	1	LS	\$5,000.00
	Erosion Control and Tree Protection	1	LS	\$10,000.00
	Site Clearing and Disposal			\$
	Site Grading			\$
	Site Stormwater Facilities			\$
	Site Electrical, Gas and Water Utilities			\$
	Traffic Control	160	HR	\$50.00
Miscellaneous Subtotal				\$ 18,000.00
Project Totals				
Subtotal				\$ 343,200.00
Contingency Percentage?!				10%
Added Contingency:!				\$ 34,320.00
Grand Total				\$ 377,520.00



PAINES CREEK AND STONY BROOK WATERSHED STORMWATER MITIGATION
PROJECT

TOWN OF BREWSTER, MASSACHUSETTS

5/14/10-1:00 p.m.
S&W No. 8614239

Attendees:

Charles Sumner, Brewster Town Administrator
Jim Gallagher, Brewster Conservation
Peter Johnson, Brewster Conservation Trust
Sue Leven, Brewster Town Planner

Elizabeth Taylor, Open Space and Planning Board
Dana Condit, Brewster Mill Sites/Alewife Committee
Chris Miller, Brewster Natural Resources & Shellfish
Director
Jessica Janney, Stearns & Wheeler GHD
Don Ferlow, Stearns & Wheeler GHD

Copies to:

All Attendees
Robert Bersin, Brewster DPW Superintendent
Russell Kleekamp, Stearns & Wheeler GHD
Gary Gonyea, MassDEP ARRA Project
Coordinator

1. Introductions and Sign-In Sheet (*see attached sign in sheet for contact information*)
2. Conceptual Preliminary Design Options (Don Ferlow, Senior Landscape Architect, Certified Wetlands Scientist)

Overall: Pro's and Con's the same for each conceptual design; difference lies within visual aesthetics.

Design #1: Bubbles in a Pond (open water area, deeper water pools)

Design #2: Naturalistically Undulating (visually appealing approach, movement of water through system)

Design #3: Naturalistically Undulating 2 (similar approach as Naturalistically Undulating, but more budget friendly approach (more inline with NRCS budget estimate (\$235K) submitted).

Design #4: Sharp Ridges and Wet Pools (sharper edges, stonework).

Design #5: Old Bog Channels (straight lines, water moves through a series of pathways).

Design #6: Angles, Channels and Pools combination of approaches (budget more inline with NRCS budget estimate submitted).



3. Project and Grant Funding Background (*Jessica Janney, Project Engineer*)

- Stormwater Assessment completed in 2007- 75% funded through CZM Coastal NPS Grant.
- Survey and 50% Design of Route 6A Triangle- 100% funded through ARRA 604(b) Water Quality Grant.
- Final Design/Engineering & Construction- 100% engineering expected to be funded and 75% construction through NRCS Grant.
- Project needs to be completed by November 2011 as part of NRCS grant.

4. Open Discussion

- Town needs O&M friendly design.
- Consultation with Police Dept. regarding any public safety issues/line of sight issues.
- Active seasonal area (Kate's Restaurant across street); liked idea of some open areas in design.
- Possibly signage explaining what the area is.
- Existing wood fence should remain.
- Lower Road side of Triangle used as a pull-off area for vehicles.
- Overall Conceptual Design Vote: 5 for Naturalistically Undulating 2 and 1 for Naturalistically Undulating- consensus was that a natural appearance was best for the area.

5. Next Steps

- Town requested a public education presentation; presentation to Board of Selectmen. Included will be photographs of previous projects, including phases of construction to current state.
- Jim Gallagher will discuss project concepts with Conservation Commission.



STEARNS & WHEELER
Environmental Engineers & Scientists

SIGN II'i

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TO\V::'oi' OF DRRWSTF.R, MASSACIIIISI::TfS

2009-03/AIUU 604

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<u>NAME</u>	ORG.	PHO::'oiJ:::I\o.	<u>FAX No.</u>	<u>EMAIL</u>
Jessie Young	S -O	::J. -g"Z.-;< & o	608-362-5634	jessie.jung@fl.com
Don Ferlow	stw	315 655 8161	315 655 4180	donald.ferlow@glb.com
Jim Galkayhar	is-c::..l.f.s C...:::..n...-c...	508 896 3701 x124		jgalkayhar@townofbarnstable.ma.us
Peter Johnson	H..ut.c-4-L« ,u.-fXu-. T'w.J-	508 896 3207		f J · aue. & _ r'f AC. • CtA f
Sue Leven	fe.r- ?(CV"lnt Of.r..... P..- ..	508 896 3701 x150 508 896 3701 128	 e*w . b{""(-4>J\$ - 1"1-D... ..> (... .. "e- 4' ..ic-L... (... .. "e- 4' ..ic-L... ! ? ; (" (.) , i e > . (: : . 1) 1 " + l . fi . J l) - : : . . " * , A u Q . : x . l . 2 . .
Donald Gendler	Open Space & Planning Alameda Comm.	508-896-3701 x147 508-886-6194		

Appendix C

Board of Selectmen Presentation of Project
June 21, 2010

Paines Creek and Stony Brook Watershed Stormwater Mitigation Project: Route 6A Triangle



2009-03/ ARRA 604

Water Quality Management Planning Grant Program

PRESENTATION TO
BREWSTER BOARD OF SELECTMEN
JUNE 21,2010



STEARNS & WHEELER
CLIENTS | PEOPLE | PERFORMANCE



PAINES CREEK AND STONY BROOK WATERSHED STORMWATER MITIGATION PROJECT: ROUTE 6A TRIANGLE

This project has been recognized and endorsed by the Massachusetts Office of Coastal Zone Management and Department of Environmental Protection. The project history began with a stormwater mitigation assessment project for Paines Creek and the Stony Brook Watershed which was completed during fiscal year 2007 as part of the CZM Coastal NPS grant program. The Stony Brook subwatershed in Brewster extends from its headwaters in Walkers Pond and Slough Pond down through Upper Mill Pond, Lower Mill Pond, along Stony Brook, and into Paines Creek (the tidal estuary to Stony Brook) which discharges into Cape Cod Bay. This assessment project identified four priority sites:

Stony Brook Mill Site (Site No. 1); was funded through a fiscal year 2008 CZM CPR grant for final design and is currently in the implementation/construction phase with 60% funding from the s.319 NPS grant program.

Paines Creek Road South of the Route 6A intersection (Site No. 3); this project is in the final design phase for stormwater improvements and is 75 percent funded through a FY2010 Coastal Zone Management (CZM) Coastal Pollutant Remediation grant.

Route 6A Triangle (Site No. 2) and **Paines Creek Road North of the Route 6A intersection** (Site No. 4); are being fully funded (\$58,000) for the 50% design with assistance from the fiscal year 2009 MassDEP 604(b) Water Quality Management Planning Grant Program assisted by the ARRA.

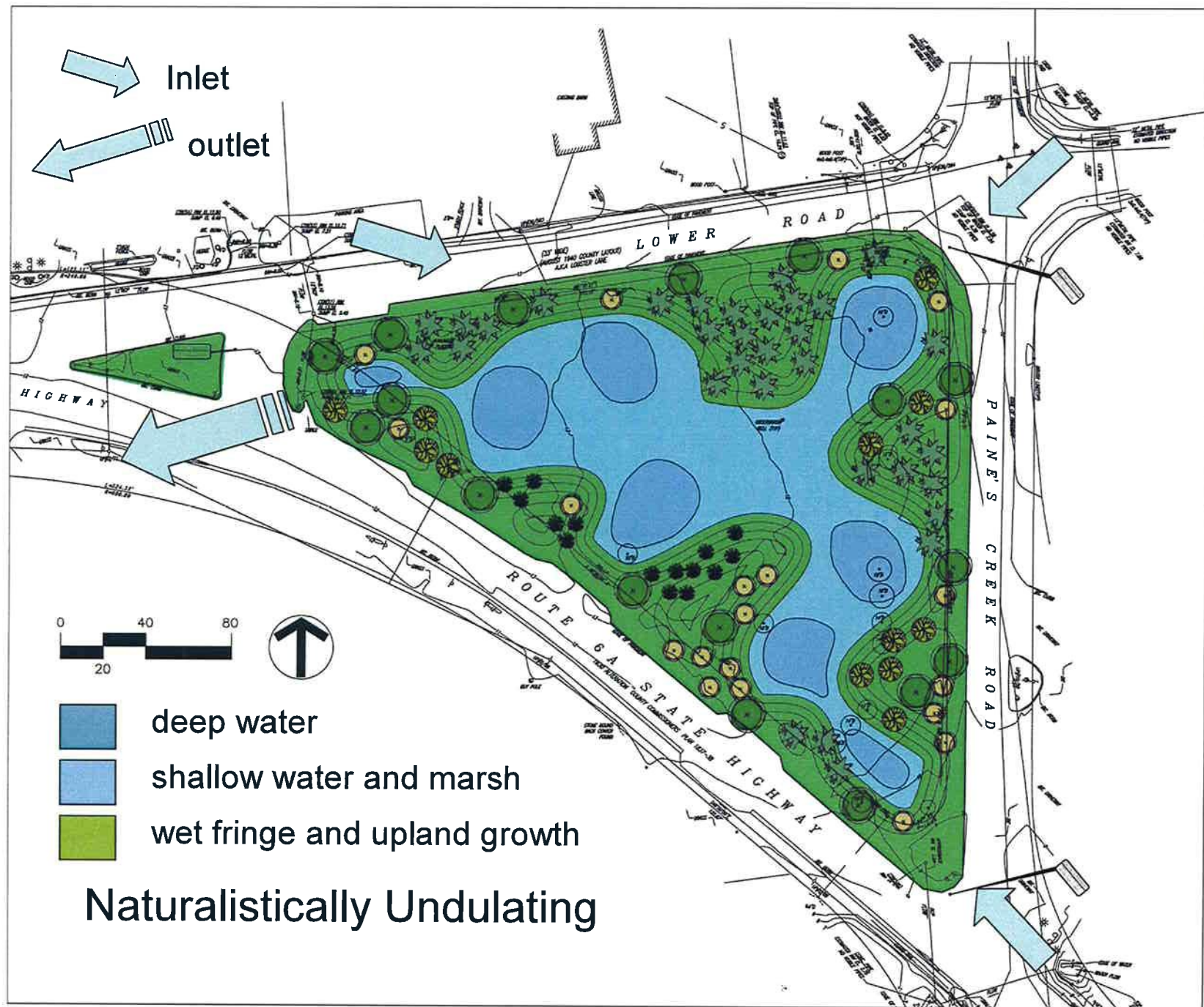
To further this project, the Town has applied for a USDA NRCS grant for the Route 6A Triangle to complete the final design and construct the stormwater improvements.

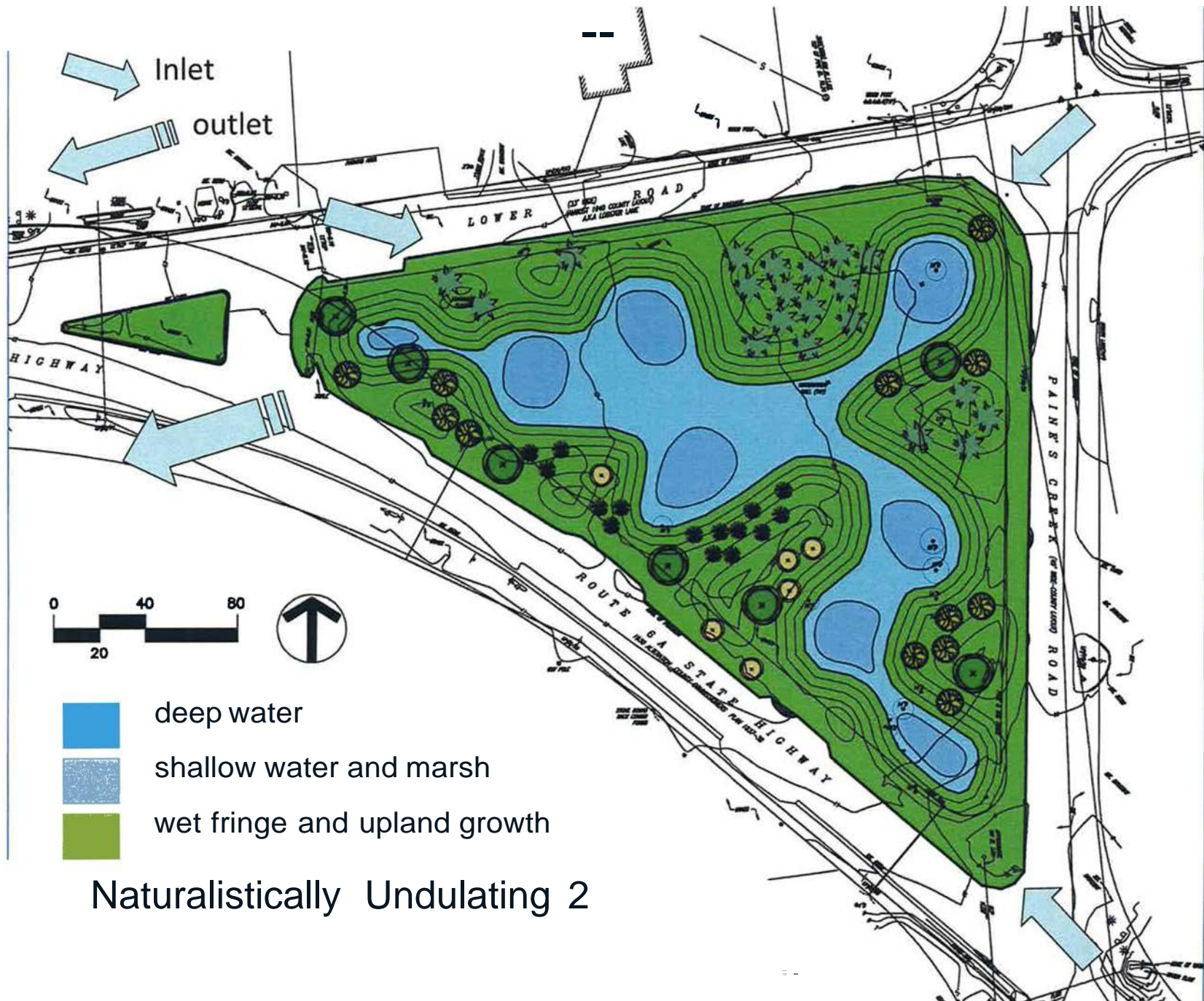
The estimated construction cost of the project= \$235,000

If the NRCS application is approved, the conditions include:

- 100% Funding for the Final Design
- 75% Funding for Construction

The Town will be required to match 25% for construction and for permitting costs. Please see the two attached conceptual designs that were supported during a progress meeting on May 14, 2010 and a preliminary design drawing which has been developed as a result of the conceptual design meeting.







1989



1989



1990



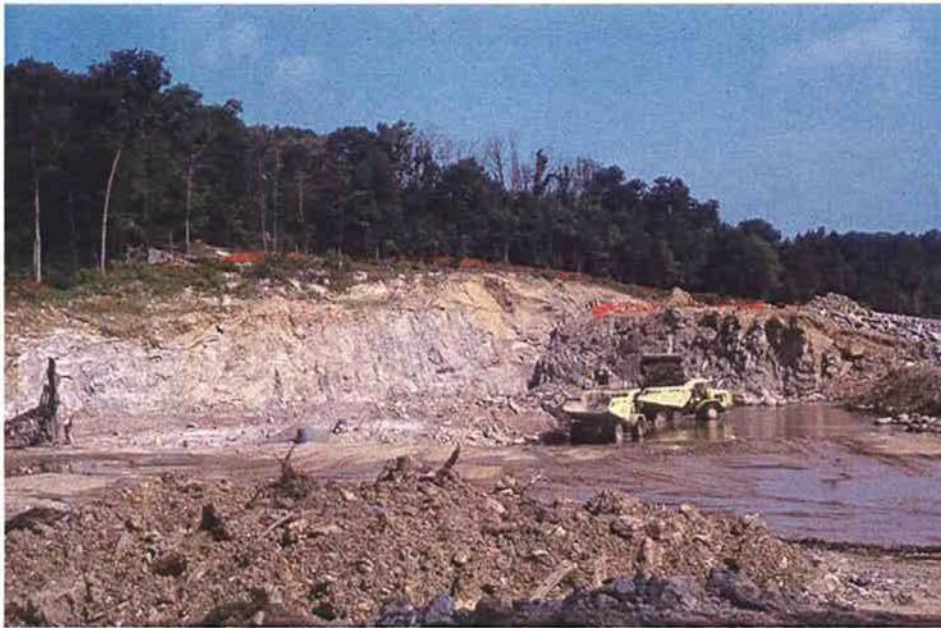
1992



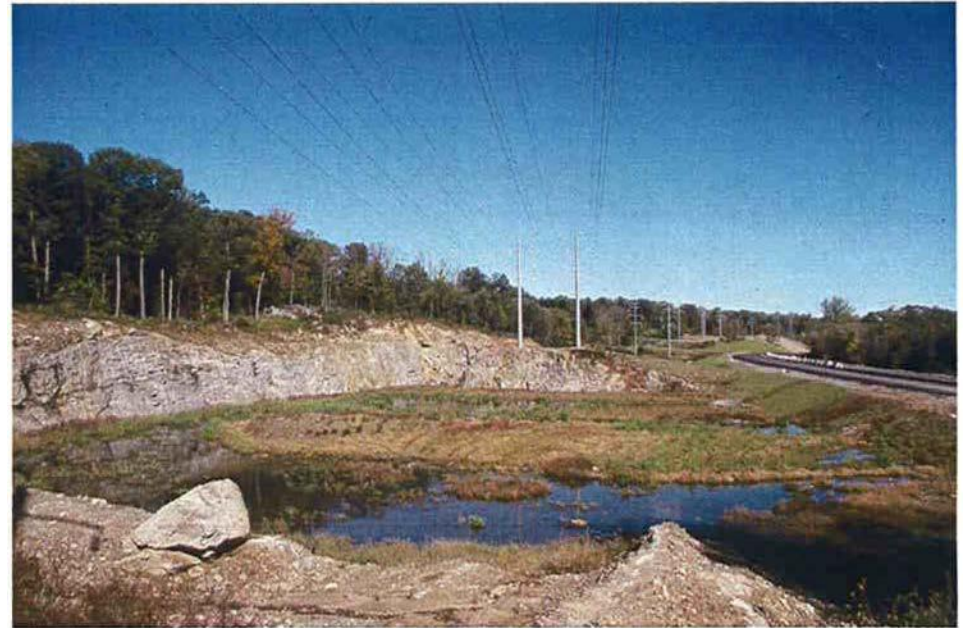
2001



2003



1989



1990

Route 7 Wetland 7



2001



2008

Appendix D

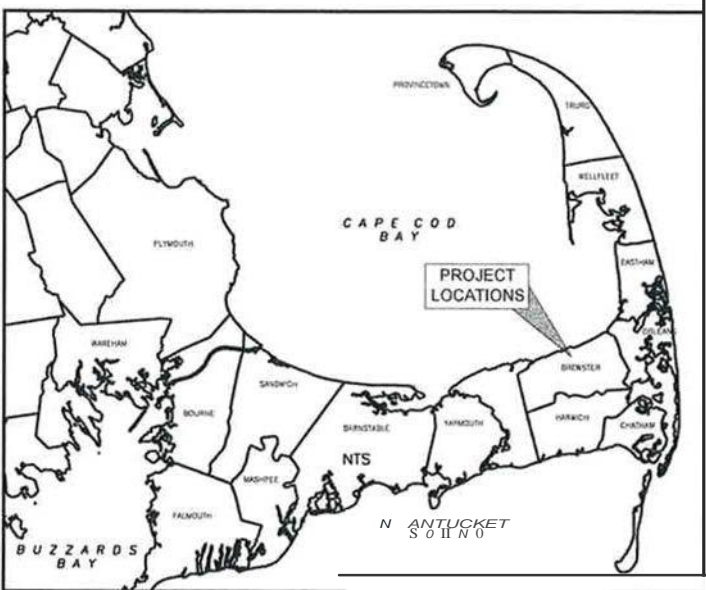
50% Design Plans
Paines Creek and Stony Brook Watershed
Stormwater Mitigation Project"
January, 2011

TOWN OF BREWSTER, MA

PAINES CREEK AND STONY BROOK WATERSHED

STORMWATER MITIGATION PROJECT

CONTRACT No. 2009-03/ARRA 604



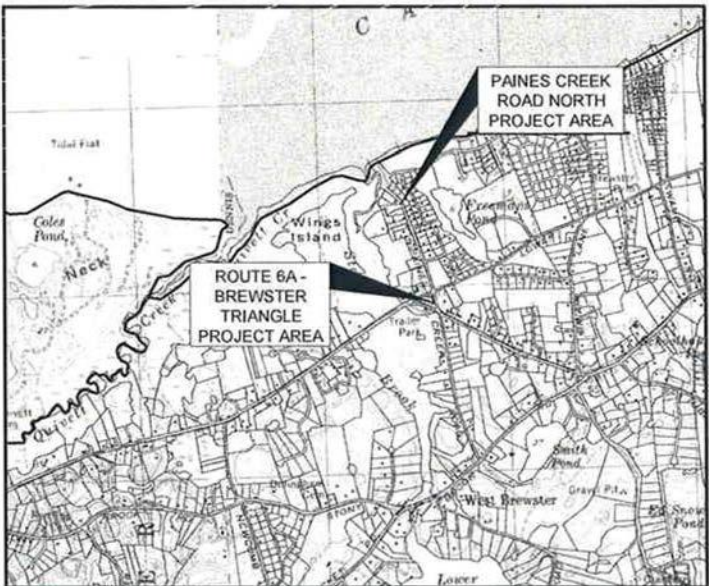
VICINITY MAP

JANUARY, 2011

STEARN & WHEELER JOB NO. 8614363

DRAWING LIST

DRG No.	DRAWING NAME
86-1423 0001	COVER SHEET
B6-1423 C001	PAINES CREEK ROAD NORTH- SITE PLAN
86-1423 2	ROUTE 6A TRIANGLE- SITE PLAN & DETAILS
86-1423 003	ROUTE 6A TRIANGLE- PLANTINGS PLAN
86-1423 C004	ROUTE 6A TRIANGLE- GRAPHIC SITE SECTIONS
B6-14239-C005	MISCELLANEOUS NOTES & DETAILS



AREA MAP

SCALE: 1" = 500'

PRELIMINARY

1	50% DESIGN REVIEW	JJO	RHK	01111
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File	Revision	Note: * Indicates signature on original form of drawing or last revision of drawing	Drawn	Checked	Approved	Date
File Date:	6 January 2011 - 5:57 PM					
Client File No:	G:\8514239\CAD\001\14230000.dwg					

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T 508 362 5660 F 508 362 5614
E hycmc@ghd.com W www.ghd.com

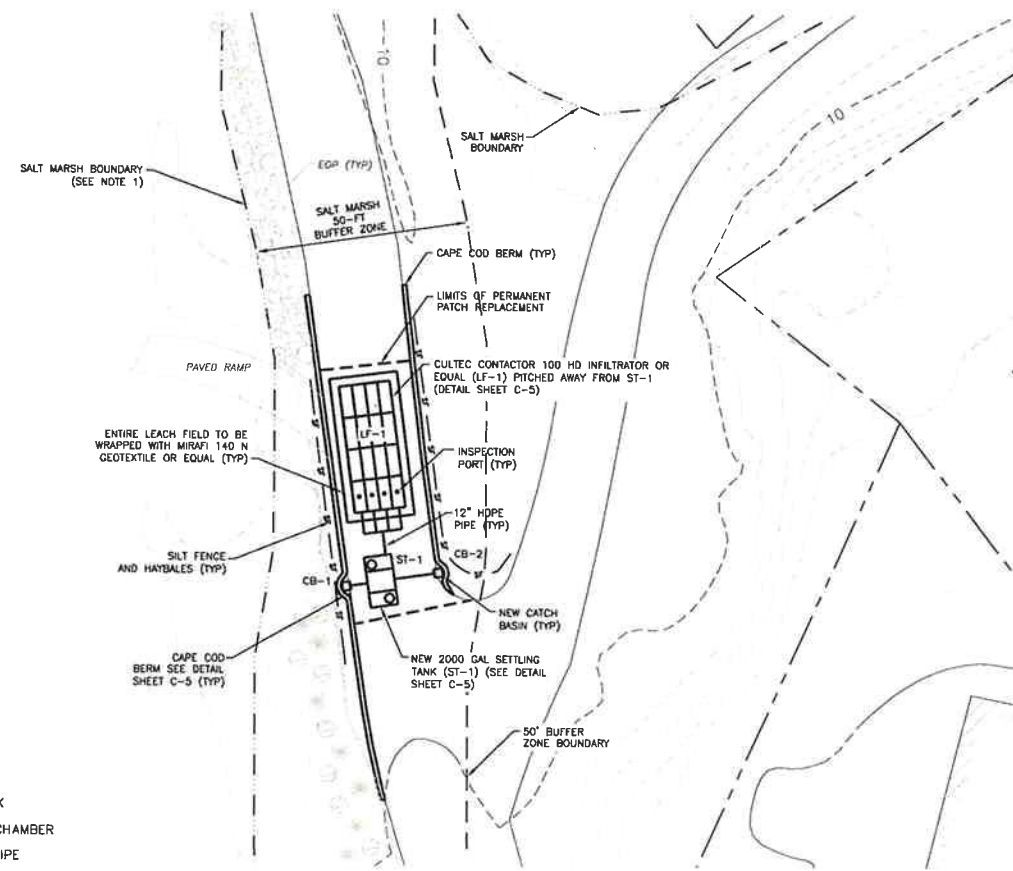
DO NOT SCALE

Client: TOWN OF BREWSTER, MASSACHUSETTS

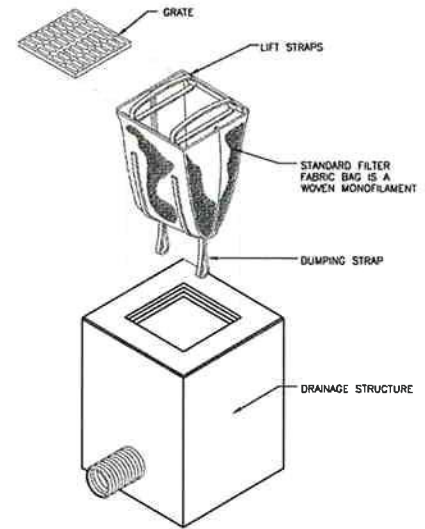
Project: STORMWATER IMPROVEMENTS

Rev: 1

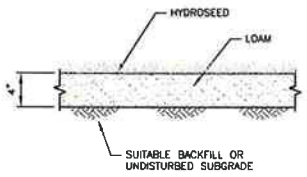
COVER PAGE



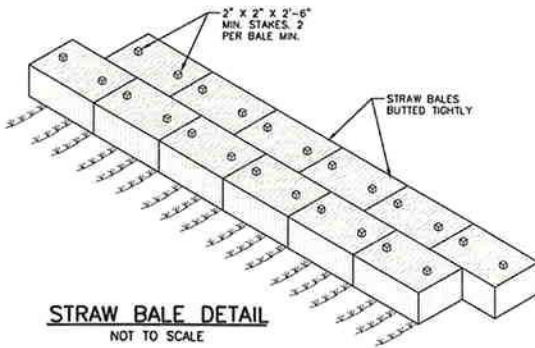
INVERT SCHEDULE	
CATCH BASIN (CB-1):	
CB-1 RIM ELEVATION:	MATCH EXISTING
CB-1 INV OUT TO ST-1:	7.1
CATCH BASIN (CB-2):	
CB-2 RIM ELEVATION:	MATCH EXISTING
CB-2 INV OUT TO ST-1:	7.1
SETTLING TANK (ST-1):	
ST-1 RIM ELEVATION:	MATCH EXISTING
ST-1 INV IN FROM CB-1:	6.85
ST-1 INV IN FROM CB-2:	6.85
ST-1 OUT TO LF-1:	6.75
LEACH FIELD 1 (LF-1):	
LF-1 RIM ELEVATION (ALL):	MATCH EXISTING
LF-1 INV IN FROM ST-1:	6.66



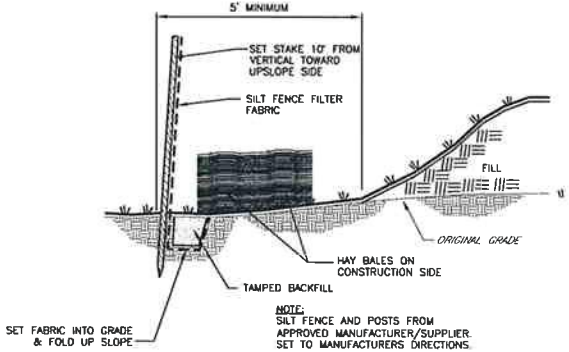
EROSION CONTROL AT CATCH BASIN
NOT TO SCALE



LOAM AND SEED - SECTION
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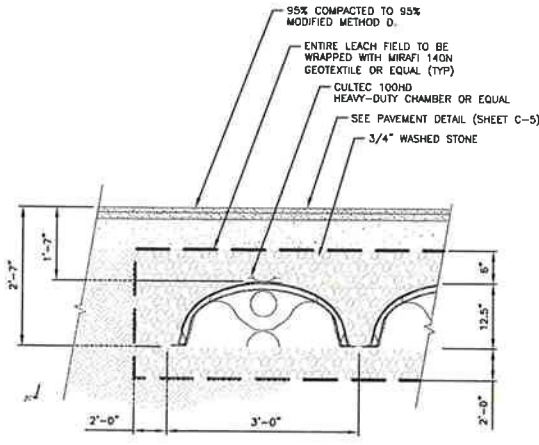
STRAW BALE DETAIL
NOT TO SCALE



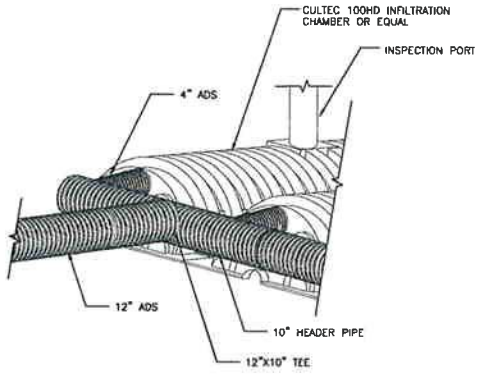
SILT FENCE INSTALLATION SCHEMATIC
NOT TO SCALE

- LEGEND**
- PROPOSED SETTLING TANK
 - PROPOSED INFILTRATION CHAMBER
 - PROPOSED HDPE DRAIN PIPE
 - PROPOSED CATCH BASIN
 - LIMIT OF PERMANENT PAVEMENT REPLACEMENT
 - SILT FENCE

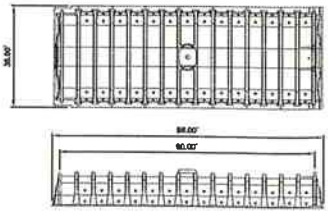
PAINES CREEK ROAD NORTH-PLAN
SCALE: 1" = 20'-0"



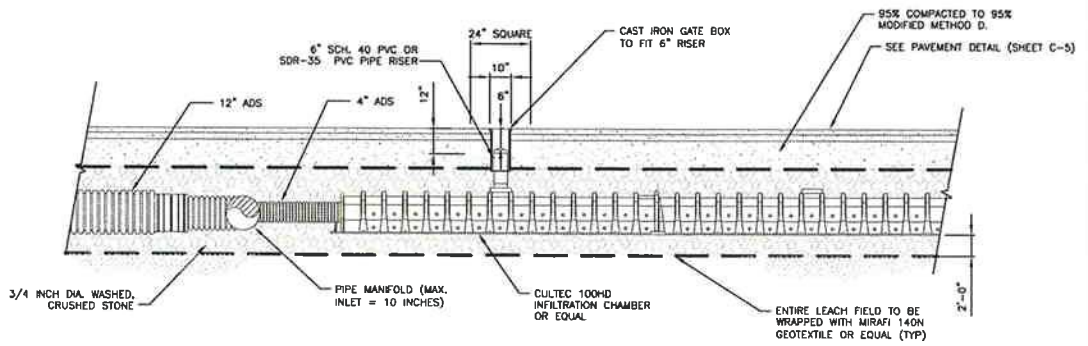
HEAVY DUTY INFILTRATOR CHAMBER SYSTEM
TYPICAL CROSS SECTION DETAIL
NOT TO SCALE



HEAVY DUTY INFILTRATOR CHAMBER SYSTEM
HEADER DETAIL
NOT TO SCALE



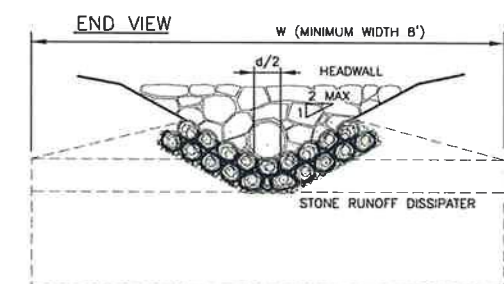
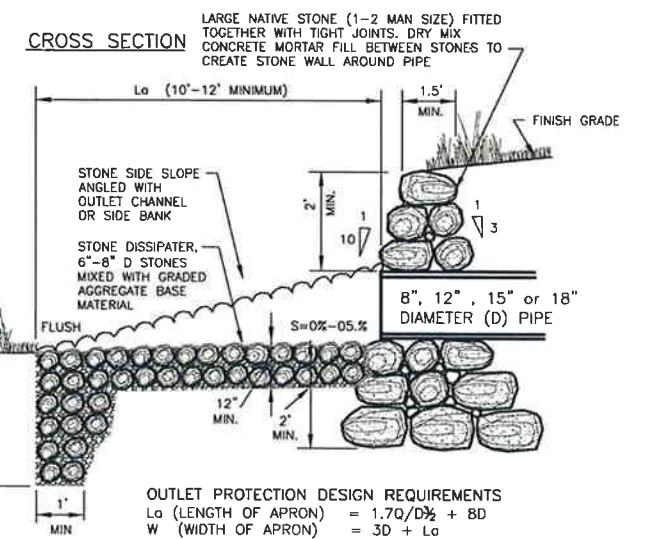
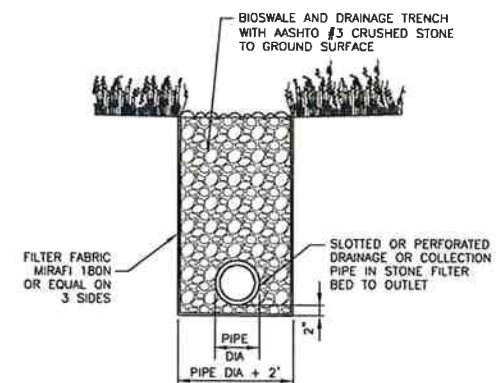
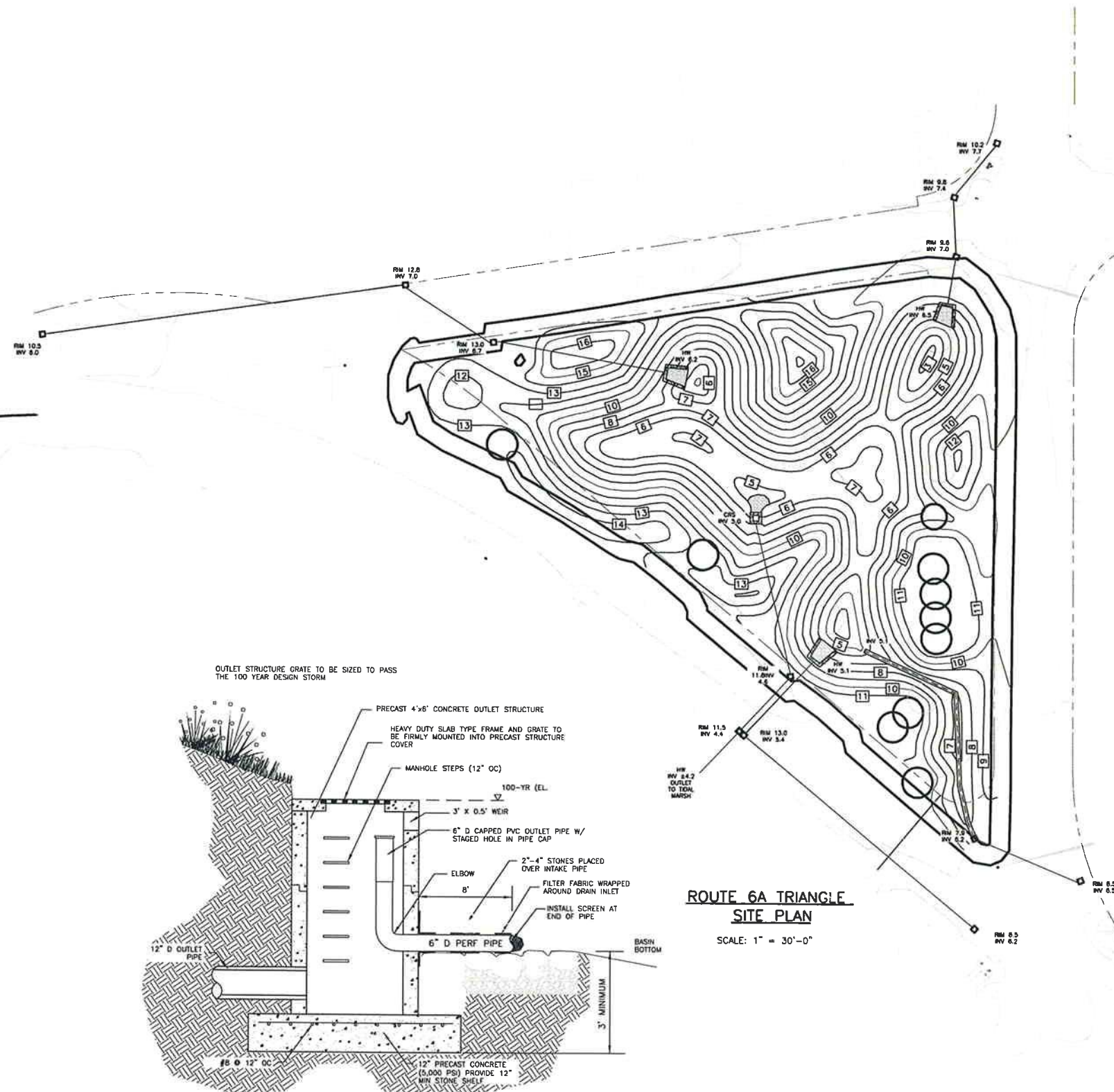
HEAVY DUTY INFILTRATOR CHAMBER SYSTEM
TYPICAL PLAN AND PROFILE
NOT TO SCALE



HEAVY DUTY INFILTRATOR CHAMBER SYSTEM
TYPICAL CROSS SECTION DETAIL
NOT TO SCALE

PRELIMINARY

<div> CLIENTS PEOPLE PERFORMANCE </div> <div> 1545 Iyannough Road, Hyannis Massachusetts 02715 USA T 1 508 362 5680 F 1 508 362 5684 E hyamail@ghd.com W www.ghd.com </div>						DO NOT SCALE		Drawn JJO Drafting Check JDF Approved Date Scale AS SHOWN	Designed RHK Design Check RHK	Client TOWN OF BREWSTER, MASSACHUSETTS Project STORMWATER IMPROVEMENTS Title PAINES CREEK ROAD NORTH - SITE PLAN
1	50% DESIGN REVIEW	JJO	RHK	01/11		Original Set Arch D Drawing No: 86-14239-C001		Rev: 1		



STONE HEADWALL AND OUTLET PROTECTION
NOT TO SCALE

DETENTION BASIN OUTLET DI6
NOT TO SCALE

1	50% DESIGN REVIEW			DLF	RHK	01/2011
No	Revision	Note: * indicates signatures on original issue of drawing or last revision of drawing	Drawn	Checked	Approved	Date

NEW PLANT MATERIAL LEGEND

PLANT MATERIALS SELECTED FOR COASTAL AREA USE
PLUS PRESENCE ON SITE OR IN NEIGHBORHOOD



EVERGREEN TREES @ 5-6-7 Foot, B&B, full

Pitch Pine, Pinus rigida
White Pine, Pinus strobus
Northern Arborvitae, Thuja occidentalis
Eastern Red Cedar, Juniperus virginiana
American Holly, Ilex, opaca



DECIDUOUS TREES

Major @ 2-2 1/2-3 1/2 Inch Caliper, B&B
Also 3'-4'-5' Height, Bareroot Stock

Black Cherry, Prunus serotina
White Oak, Quercus alba
Scarlet Oak, Quercus coccinea
Red Oak, Quercus rubra
Black Tupelo, Nyssa sylvatica
Red Maple, Acer rubrum



Flowering/Minor @ 6-7-8 Foot Height, B&B/Container
Also 3'-4'-5' Height, Bareroot Stock

Bacch Plum, Prunus maritima
Gray Birch, Betula populifolia
Serviceberry, Amelanchier arborea
Shadbush, Amelanchier canadense
Pussy Willow, Salix discolor Molai
Speckled Alder, Alnus incana var. rugosa



SHRUBS AND GROUND COVERS - #1, #2, #3 Containers

Cinquefoil, Potentilla fruticosa
Sumacs (Not Poison), Rhus typhina/copallina
Pasture Rose, Rosa carolina
Virginia Rose, Rosa virginiana
Bayberry, Myrica pensylvanica
Highbush Cranberry, Viburnum trilobum
Inkberry, Ilex glabra

Silky Dogwood, Cornus amomum
Gray Dogwood, Cornus racemosa
Red-osier Dogwood, Cornus sericea
Meadowsweet, Spiraea latifolia
Hardhack/Steeplebush, Spiraea tomentosa
Elderberry, Sambucus canadensis
Bullbush, Cephalanthus occidentalis
Sweet Fern, Comptonia peregrina
Horizonal Juniper, Juniperus horizontalis

GRASSES AND WILDFLOWERS - #1, #2 Containers

Switch Grass, Panicum virgatum
Red Fescue, Festuca rubra
Sheep Fescue, Festuca ovina
Perennial Ryegrass, Lolium perenne
Little Bluestem, Schizochyrium scoparium
Milkweed, Asclepias tuberosa
Golden Aster, Chrysopsis foliolata
Aster, Aster spp.
Goldenrod, Solidago spp.
Joe Pye Weed, Eupatorium spp.
Boneset, Eupatorium perfoliatum
Goldenrod, Euthamia tenuifolia

SELECTION OF THE ACTUAL SPECIES USED FOR ANY ONE GIVEN
AREA WILL DEPEND UPON PLANT AVAILABILITY, PLANT QUALITY AT A
NURSERY SOURCE, AND VISUAL CHARACTER DESIRED WITHIN THE
LANDSCAPE. SPECIES USED SHALL HAVE A SIMILAR ENVIRONMENTAL
CHARACTER.

EXISTING TREES AND SHRUBS



PLANTINGS SITE PLAN
SCALE: 1" = 30'-0"

NOTES:

IF TOPSOIL IS COMPACTED AND HARD,
BEFORE PLANTING ADD 3"-4" OF WELL
COMPOSTED LEAVES AND INCORPORATE
INTO TOP 6" OF SOIL.

PLANT PIT AREA SURROUNDING ROOT
BALLS TO BE LOOSENEED AND LIGHTLY
COMPACTED BY HAND

MULCH MATERIAL SHALL BE WOOD CHIPS
OR SHREDDED BARK FROM SITE
STOCKPILES AND/OR OFF SITE SOURCES
SHOULD EXISTING MULCH NOT BE
SUFFICIENT TO COMPLETE WORK

SET TREES WITH
GROUND LINE AT SAME
ELEVATION AS EXISTED
AT THE NURSERY OR
WHEN DIRECTED SET
1"-2" HIGHER THAN
EXISTING GROUND LEVEL

3" SOIL SAUCER
SOIL SAUCER
OR LAWN

NOTE: WRAP
DECIDUOUS
TREES OVER 2"
CALIPER

TAMP SOIL
FIRMLY
AROUND
ROOT BALL
SIZE BASED UPON SOIL TYPE
5'-6" DIAMETER MINIMUM

PLANT PIT DEPTH BELOW
ROOT BALL TO BE 4" TO
6" FOR PLANTS UP TO
3.5" CAL AND 8" MIN
FOR LARGER PLANTS

SET ROOT BALL ON FIRM
PAD IN BOTTOM OF HOLE

5'-6" DIAMETER MINIMUM

5'-6" DIAMETER MINIMUM

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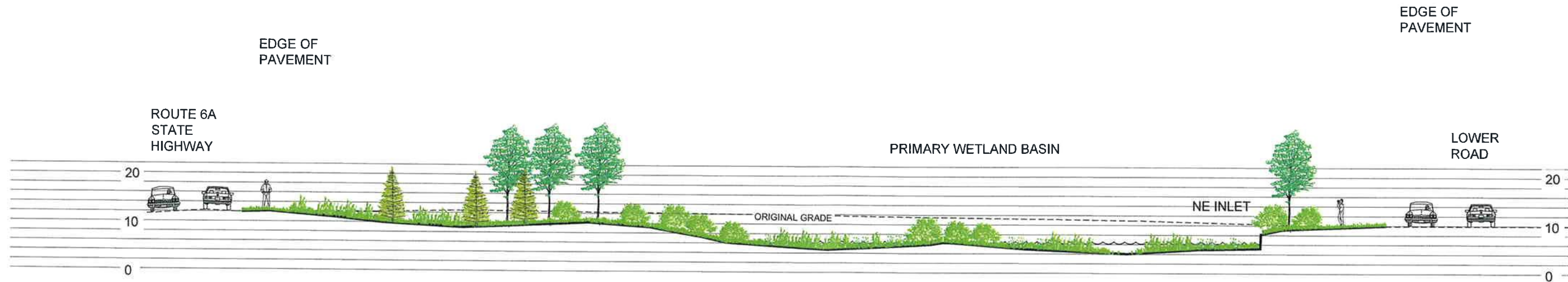
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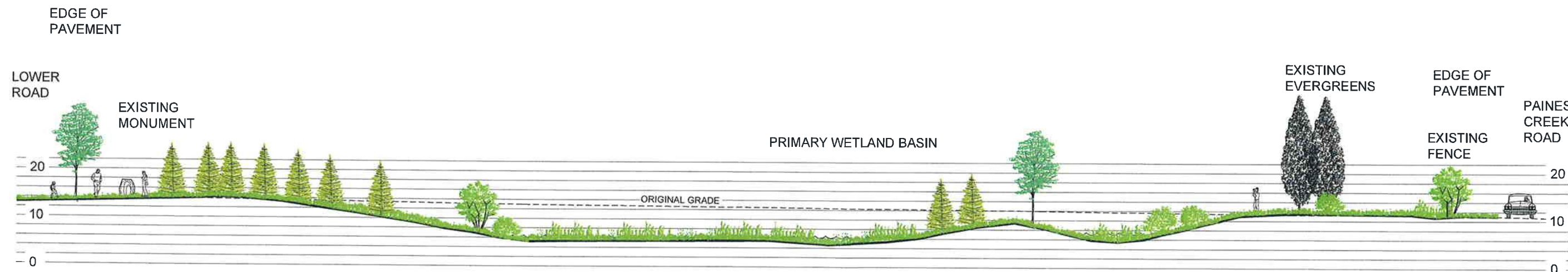
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5'-6" DIAMETER MINIMUM

5'-6" DIAMETER MINIMUM



NORTH/SOUTH SECTION



EAST/WEST SECTION

GRAPHIC SITE SECTIONS

VERTICAL AND HORIZONTAL SCALE EQUAL

PRELIMINARY

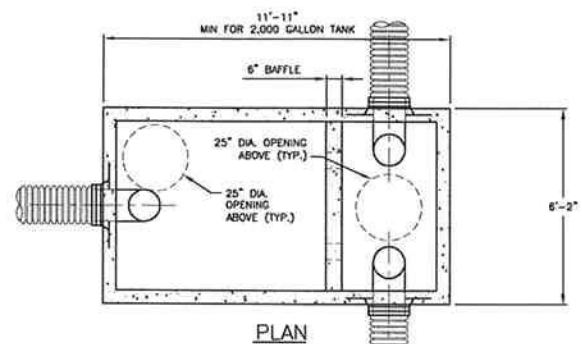
					 CLIENTS PEOPLE PERFORMANCE	DO NOT SCALE	Drawn: DLF Drafting Check: JDF Approved: _____ Date: _____	Designed: DLF Design Check: RHK _____ Date: _____	Client: TOWN OF BREWSTER, MASSACHUSETTS Project: STORMWATER IMPROVEMENTS Title: ROUTE 6A TRIANGLE GRAPHIC SITE SECTIONS
1	50% DESIGN REVIEW		DLF	RHK	01/2011	1545 Iyannough Road, Hyannis Massachusetts 02715 USA T 1 508 362 5680 F 1 508 362 5684 E hyamail@ghd.com W www.ghd.com	Conditions of Use: This document may only be used by GHD's client (and any other person who GHD has agreed can use this document) for the purpose for which it was prepared and must not be used by any other person or for any other purpose.	Scale: AS SHOWN This Drawing must not be used for construction unless signed as Approved	Arch D Drawing No: 86-14239-C004 Rev: 1

1. THIS PROJECT HAS BEEN FINANCED PARTIALLY WITH FEDERAL FUNDS FROM THE ENVIRONMENTAL PROTECTION AGENCY (EPA) TO THE MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION (THE DEPARTMENT) UNDER AN AMERICAN RECOVERY AND REINVESTMENT ACT OF 2009 SECTION 604(b) WATER QUALITY MANAGEMENT PLANNING GRANT. THE CONTENTS DO NOT NECESSARILY REFLECT THE VIEWS AND POLICIES OF THE EPA OR THE DEPARTMENT, NOR DOES THE MENTION OF TRADE NAMES OR COMMERCIAL PRODUCTS CONSTITUTE ENDORSEMENT OR RECOMMENDATION FOR USE.

-
- STANDARD PRECAST CONCRETE CATCH BASIN
- NOT TO SCALE
- 6" MIN. STANDARD DEPTH
- 18"-24" HEIGHT OF RISER SECTION VARIES FROM 1" TO 4"
- 5" (MIN.)
- 4"-0" SUMP (MIN.)
- 4"-0" DIA.
- 24" SQUARE OPENING
- 8" (MIN.)
- WEEP HOLE
- RUBBER JOINT SEALANT CONFORMING TO ASTM C 361
- KENT SEAL RUBBER GASKET (TYP.)
- PIPE SHALL BE 12" HDPE PIPE, SUITABLE FOR H2O LOADING, UNLESS OTHERWISE SPECIFIED ON THE DRAWINGS
- OUTSIDE DIA. OF PIPE PLUS 2"
- PROVIDE "V" OPENINGS (TYP.)
- PRECAST CONCRETE UNIT WITH OPEN BOTTOM
- SET FRAME IN A FULL BED OF MORTAR
- SURFACE TREATMENT (SEE DETAIL THIS SHEET)
- FRAME AND GRATE SHALL BE LEBARON TYPE F CATALOG NO. LF 248 (6" HEIGHT) OR EQUAL OR APPROVED EQUAL
- AFTER BINDER COURSE OF ASPHALT CONCRETE HAS BEEN PLACED, EXCAVATE MATERIAL AT FRAME AND RESET FRAME TO FINISHED GRADE. FILL EXCAVATED AREA AROUND FRAME WITH NON-SHRINK GROUT TO TOP OF BINDER COURSE
- BRICKS MAY BE USED FOR GRADE ADJUSTMENTS (2 MIN.-12" MAX.)

NOTES:

1. EXTERIOR SURFACES TO BE SEALED WITH COLD APPLIED BITUMINOUS SEALER.
2. REINFORCEMENT SHALL BE MIN. 0.12 SQ. IN. PER VERTICAL FOOT, PLACED IN ACCORDANCE WITH AASHTO DESIGNATION M-199.
3. CONCRETE SHALL BE 4000 PSI.
4. FACE OF PIPE FLUSH OR NOT TO PROJECT MORE THAN 4-IN. FROM FACE OF WALL ALONG CENTERLINE OF PIPE.
5. ENTIRE STRUCTURE SHALL BE DESIGNED TO SUPPORT HS-20 LOADING.
6. PROVIDE 6'-0" DIAMETER FLAT TOP CATCH BASIN FOR CB-3 (DOUBLE GRATE CATCH BASIN).



1-1/2" CLASS 1 TOP COURSE OF MASS HIGHWAY MATERIAL W3.11.00

2-1/2" CLASS 1 BINDER COURSE OF MASS HIGHWAY MATERIAL W3.11.00

12" CUTBACK (TYPICAL)

EXIST. PAVEMENT

6" GRAVEL SUBBASE

COMMON ROCK

1. SAFETY STANDARDS MAY DICTATE A MODIFICATION IN TRENCH SIDE SLOPES. CONTRACTOR IS RESPONSIBLE FOR MEETING ALL APPLICABLE SAFETY STANDARDS.

2. PLEASE REFERENCE SECTION X-2, "RECOMMENDATIONS FOR INCORPORATION INTO CONTRACT DOCUMENTS" OF ASTM SPECIFICATION D2321, "STANDARD PRACTICE FOR UNDERGROUND INSTALLATION OF THERMOPLASTIC PIPE FOR SEWERS AND OTHER GRAVITY- FLOW APPLICATIONS".

SAW-CUT EXISTING DRIVE & PLACE FULL DEPTH PAVEMENT AS SPECIFIED WITH ASPHALT TACK COAT AT JOINTS

EXISTING DRIVEWAY

2" BITUMINOUS CONCRETE SURFACE COURSE - CLASS 1

2 1/2" BITUMINOUS CONCRETE BINDER COURSE - CLASS 1

6" CUTBACK REQUIRED ON ASPHALT DRIVES

R=3'-0" (TYP.)

VARIES

1-1/2" REVEAL

BITUMINOUS CONCRETE BERM (TYP.) (SEE DETAIL THIS SHEET)

MATCH EXISTING

The diagram illustrates the cross-section of a Type 'A' Berm. Key dimensions and components include:

- Top Width:** The berm has a total top width of 1'-0" on the left side and 1'-0" on the right side.
- Height:** The height of the berm is 1'-1/2".
- Reveal:** A 2" MIN REVEAL is indicated at the top edge.
- Surface Course:** The top surface is labeled as the SURFACE COURSE.
- Existing Disturbed Pavement:** The area to the left of the berm is labeled as EXISTING DISTURBED PAVEMENT.
- Type 'A' Berm:** The central raised portion is labeled as TYPE "A" BERM.
- Hydroseeded Area:** The sloped sides of the berm are labeled as HYDROSEEDED AREA.
- Loam and Disturbed Soil:** The base of the berm is labeled as LOAM AND DISTURBED SOIL.

PRELIMINARY

										 CLIENTS PEOPLE PERFORMANCE		DO NOT SCALE		Drawn JJO Designed RHK		Client TOWN OF BREWSTER, MASSACHUSETTS	
										1545 Iyanough Road, Hyannis Massachusetts 02715 USA T 1 508 362 5680 F 1 508 362 5684 E hyannis@ghd.com W www.ghd.com		Conditions of Use. This document may only be used by GHD's client (and any other person who GHD has agreed can use this document) for the purpose for which it was prepared and must not be used by any other person or for any other purpose.		Drafting Check JDF Design Check RHK		Project STORMWATER IMPROVEMENTS	
												Approved Date		Title ROUTE 6A TRIANGLE - MISCELLANEOUS DETAILS			
												Scale AS SHOWN		Original Size Arch D			
												This Drawing must not be used for Construction unless signed as Approved		Drawing No: 86-14239-C005			
														Rev: 1			

Appendix E

Pollutant Removal Quantities and Calculations Watershed-Based Plan for the Cape Cod Basin Excerpts

Volume 2 Chapter 2: Structural BMP Specifications for the Massachusetts Stormwater Handbook Excerpts

Brewster Paines Creek Road - "North" Stormwater Improvements
Estimated Quantity of Pollutants to be Removed

	Area (acres) (Imp + Perv) ³	TSS (lb/acre-ft)	F. coli (counts/acre-ft)	Precipitation (in/yr) ⁴	TSS load (lbs/yr)	F. coli load (counts/yr)	%Removal	TSS Removed (lbs/yr)	F. coli Removed (counts/yr)
Paines Creek Road !"North"	12.48	6.9	2.2E+09	45	323.7	1.0E+11	80%	259	8.09E+10

	Area (acres) (Imp + Perv) ³	TP (lb/acre-ft)	TN (lb/acre-ft)	Precipitation (in/yr) ⁴	TP load (lbs/yr)	TN load (lbs/yr)	%Removal	TP Removed (lbs/yr)	TN Removed (lbs/yr)
Paines Creek Road !"North"	12.48	0.2	2.0	45	7.4	94.4	80%	6	76

<u>Equation:</u> 50th percentile load HUC cell flow	=	concentration (lbs/acre-ft ; counts/acre-ft)
---	---	--

TSS Example(SJ):

$$\frac{960,000 \text{ lbs/yr}^1}{138,779 \text{ ac-ft/yr}^2} = 6.9 \text{ lbs/acre-ft}$$

$$6.9 \text{ lbs} \times 54.80^{(3)} \text{ acres} = 379.1 \text{ lbs/ft}$$

$$\frac{379.1 \text{ lbs}}{\text{ft}} \times \frac{45 \text{ in}^4}{\text{yr} \times 12 \text{ in}} = 1,421.5 \text{ lbs/yr of TSS}$$

BMP @ 80% Removal:

$$1421.5 \text{ lbs/yr} \times 80\% = 1,137 \text{ lbs/yr of TSS}$$

NOTES:

1. SO% TSS LF value for Monomoy Groundwater Flow Cell, Table 21, p. 26 of "Technical Memorandum, Watershed-Based Plan for the Cape Cod Basin," (Watershed-Based Plan) Prepared for MassDEP.
2. Flow for Monomoy Groundwater Flow Cell, Table 15, p. 19 of Watershed-Based Plan.
3. Total acreage of pervious (drainage) area+ impervious area
4. Precipitation (in/yr) from Figure 3, p. 5 of the Watershed-Based Plan.
5. Repeat Calculations to determine TP, TN and Fecal Coliform removals using 50% LF from Table 22, Table 23 and Table 24, respectively, on p. 26 of the Watershed-Based Plan.

Brewster Route SA Triangle Stormwater Improvements
Estimated Quantity of Pollutants to be Removed

	Area (acres) (Imp + Perv) ³	TSS (lb/acre-ft)	F. coli (counts/acre-ft)	Precipitation (in/yr) ⁴	TSS load (lbs/yr)	F. coli load (counts/yr)	%Removal	%Removal	TSS Removed (lbs/yr)	F. coli Removed (counts/yr)
Route 6A Triangle	22.60	6.9	2.2E+09	45	586.3	1.8E+11	80%	75%	469	1.37E+11

	Area (acres) (Imp + Perv)(3)	TP (lb/acre-ft)	TN (lb/acre-ft)	Precipitation (in/yr) ⁴	TP load (lbs/yr)	TN load (lbs/yr)	%Removal TP	%Removal TN	TP Removed (lbs/yr)	TN Removed (lbs/yr)
Route 6A Triangle	22.60	0.2	2.0	45	13.5	171.0	40%	40%	5	68
							60%	60%	8	103

Equation:
50th percentile load
HUC cell flow

TSS Example (SI):
960,000 lbs/yr¹
138,779 ac-ft/yr²
6.9 lbs x 54.80³ acres
acre-ft
379.1 lbs x $\frac{45 \text{ in}^4}{12 \text{ in}}$ x 1.1 ft⁴ :: 1,421.5 lbs/yr of TSS
BMP @ 80% Removal:
1421.5 lbs/yr x 80%

NOTES:

1. 50% TSS LF value for Monomoy Groundwater Flow Cell, Table 21, p. 26 of "Technical Memorandum, Watershed-Based Plan for the Cape Cod Basin," (Watershed-Based Plan) Prepared for MassDEP.
2. Flow for Monomoy Groundwater Flow Cell, Table 15, p. 19 of Watershed-Based Plan.
3. Total acreage of pervious (drainage) area+ impervious area
4. Precipitation (in/yr) from Figure 3, p.5 of the Watershed-Based Plan.
5. Repeat Calculations to determine TP, TN and Fecal Coliform removals using 50% LF from Table 22, Table 23 and Table 24, respectively, on p. 26 of the Watershed-Based Plan.

Technical Memorandum

Watershed-Based Plan

For the

Cape Cod Basin

Prepared By:

BETA Group, Inc.
6 Blackstone Valley Place
Lincoln, RI 02865

Applied Technology & Management, Inc.
360 Thames Street, Suite 1B
Newport, RI 02840

Baystate Environmental Consultants, Inc.
296 North Main Street
East Longmeadow, MA 01028

Prepared for:

Massachusetts Department of Environmental Protection
627 Main Street
Worcester, MA 01608

September, 2006

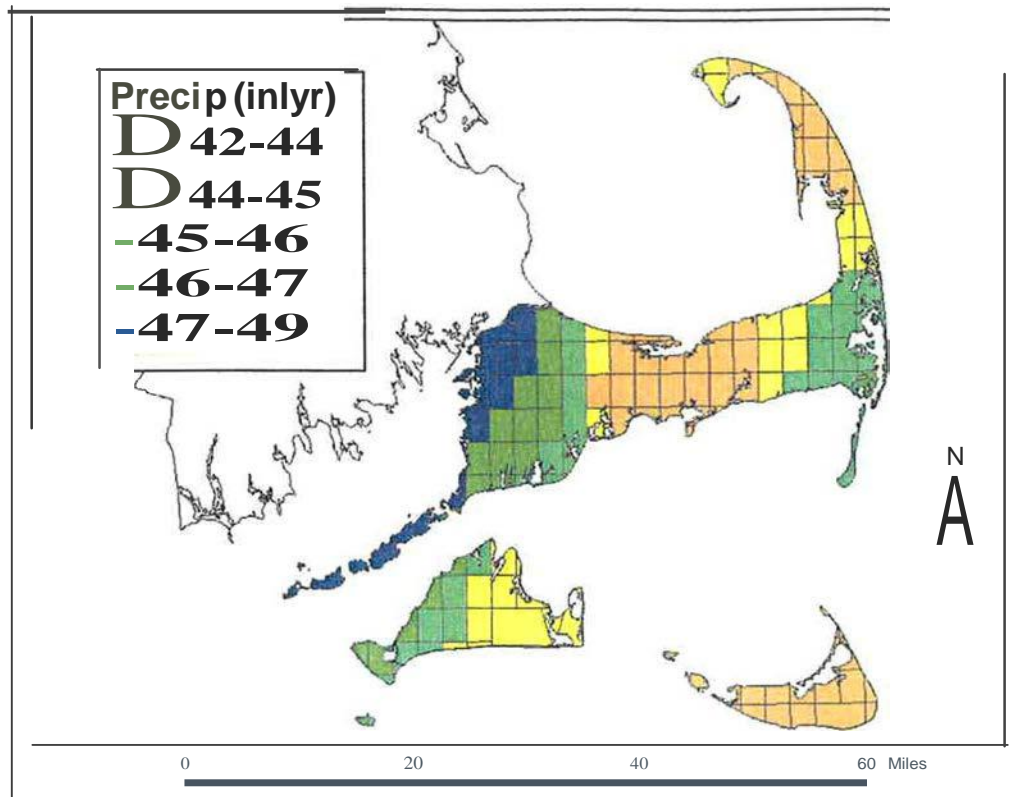


Figure 3- Oregon State University PRISM Annual Average Precipitation Layer for the Cape Cod and Islands Basins, 2000 -2004.

Land Use

Since the WMM uses land use-based Event Mean Concentrations (EMCs) as the basis for estimation of pollutant loads, a fine-scale land use layer is required for each WMM application. The January 2002 Massachusetts statewide 1:25,000 scale land use layer was acquired from the MassGIS website at <http://www.mass.gov/mgis/ftplus.htm>. To facilitate the use of this land use information within the WMM, the 36 land use categories in the layer were mapped to the following 14 encompassing categories:

Agricultural/Pasture	Industrial
Forest/Rural Open	Highways (Transportation)
Urban Open	Water/Wetlands
Low Density Residential	Cranberry Bogs
Medium Density Residential	Mining
High Density Residential	Waste Disposal
Commercial	Water-Based Recreation

Table 3 shows how the 36 MassGIS land use categories were mapped to the 14 WMM categories. Once the land use categories were remapped to these 14 categories, the land use layer was clipped with the Cape Cod basin boundary and then intersected with the 12-digit HUC layer for the basin. The total acreage of each land use category that occurs within each individual HUC was then calculated and entered into the WMM. Table 4 shows the land use acreages entered for each

Table 14 – Total Withdrawal Flows for each Cape Cod Basin Watershed

HUC	Withdrawal (ac-ft/yr)	Withdrawal (MGD)
010900020201	952	0.85
010900020202	0	0
010900020203	0	0
010900020204	41	0.04
010900020205	15,248	13.61
010900020206	35,452	31.65

Table 15 – Cape Cod Basin Flow Calibration Statistics

Gage#	Name	WMM Avg (ac-ft/yr)	Avg Obs (cfs)	Avg Obs (ac-ft/yr)	% Error
010900020201	Pilgrim Groundwater Flow Cell	16,171			
010900020202	Pamet Groundwater Flow Cell	15,325			
010900020203	Chequesset Groundwater Flow Cell	32,832			
010900020204	Nauset Groundwater Flow Cell	27,959			
010900020205	Monomoy Groundwater Flow Cell	138,779			
010900020206	Sagamore Groundwater Flow Cell	309,533			

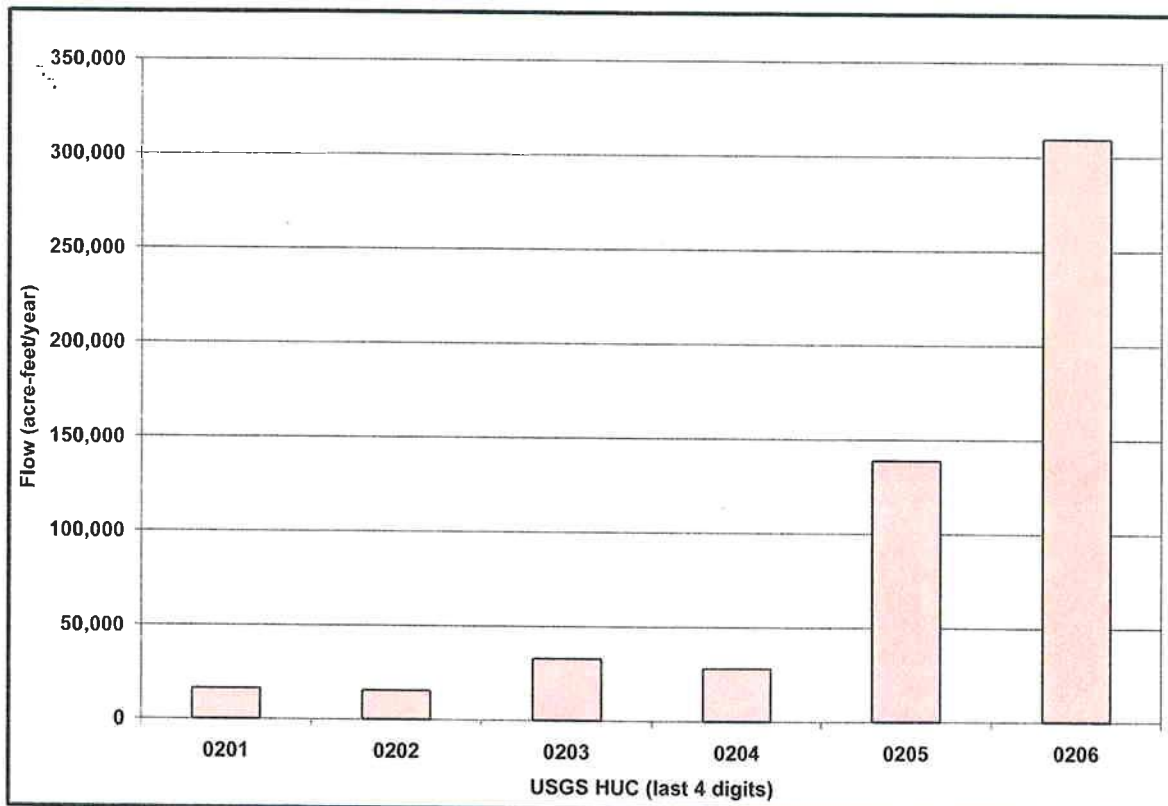


Figure 4 – WMM Flow predictions for the Cape Cod Basin

specified as 10% and 90%. Once these have been specified, the WMM uses a standard normal deviate equation to estimate the 10th percentile and 90th percentile loads, using the mean EMC specified for each land use/parameter combination and WMM default Coefficients of Variance (CVs) for each land use EMC. The default CVs were established from the USEPA NURP (National Urban Runoff Program) study results of 1983. Tables 21 through 24 also show the total acreages for each USGS HUC and the cumulative flows (cfs) estimated by the WMM for each HUC outlet point. Unlike the nonpoint source loading estimates, the flow estimates in these tables do incorporate the effects of point source discharges and withdrawals. Appendix B presents the distribution of land use categories and the predicted nonpoint source loads for each Cape Cod basin HUC.

Table 21 – WMM-Predicted Nonpoint Source TSS Loads for the Cape Cod Basin

USGS HUC ID	Subwatershed Name	Subwatershed Area (acres)	Total Flow (cfs)	TSS (lbs/yr) @ WMM Loading Factors		
				10% LF	50% LF	90% LF
010900020201	Pilgrim Groundwater Flow Cell	7,619	22.3	56,059	74,683	93,171
010900020202	Pammet Groundwater Flow Cell	7,071	21.2	53,810	69,100	84,289
010900020203	Chequesset Groundwater Flow Cell	14,874	45.3	182,653	293,542	413,542
010900020204	Nauset Groundwater Flow Cell	12,099	38.6	74,167	93,126	111,765
010900020205	Monomoy Groundwater Flow Cell	65,705	191.7	570,000	960,000	1,320,000
010900020206	Sagamore Groundwater Flow Cell	147,145	427.5	970,000	1,260,000	1,540,000

Table 22 – WMM-Predicted Nonpoint Source TP Loads for the Cape Cod Basin

USGS HUC ID	Subwatershed Name	Subwatershed Area (acres)	Total Flow (cfs)	TP (lbs/yr) @ WMM Loading Factors		
				10% LF	50% LF	90% LF
010900020201	Pilgrim Groundwater Flow Cell	7,619	22.3	1,415	1,948	2,489
010900020202	Pammet Groundwater Flow Cell	7,071	21.2	1,371	1,852	2,357
010900020203	Chequesset Groundwater Flow Cell	14,874	45.3	3,000	4,275	5,610
010900020204	Nauset Groundwater Flow Cell	12,099	38.6	2,328	3,441	4,630
010900020205	Monomoy Groundwater Flow Cell	65,705	191.7	13,940	22,090	30,702
010900020206	Sagamore Groundwater Flow Cell	147,145	427.5	30,225	45,404	61,375

Table 23 – WMM-Predicted Nonpoint Source TN Loads for the Cape Cod Basin

USGS HUC ID	Subwatershed Name	Subwatershed Area (acres)	Total Flow (cfs)	TN (lbs/yr) @ WMM Loading Factors		
				10% LF	50% LF	90% LF
010900020201	Pilgrim Groundwater Flow Cell	7,619	22.3	22,315	27,419	32,631
010900020202	Pammet Groundwater Flow Cell	7,071	21.2	21,487	26,684	32,121
010900020203	Chequesset Groundwater Flow Cell	14,874	45.3	47,723	61,887	76,666
010900020204	Nauset Groundwater Flow Cell	12,099	38.6	35,138	46,986	59,493
010900020205	Monomoy Groundwater Flow Cell	65,705	191.7	201,843	280,000	370,000
010900020206	Sagamore Groundwater Flow Cell	147,145	427.5	440,000	580,000	730,000

Table 24 – WMM-Predicted Nonpoint Source Fecal Coliform Loads for the Cape Cod Basin

USGS HUC ID	Subwatershed Name	Subwatershed Area (acres)	Total Flow (cfs)	F-Coli (counts/yr) @ WMM Loading Factors		
				10% LF	50% LF	90% LF
010900020201	Pilgrim Groundwater Flow Cell	7,619	22.3	4.20E+12	7.80E+12	1.20E+13
010900020202	Pammet Groundwater Flow Cell	7,071	21.2	3.30E+12	6.20E+12	9.00E+12
010900020203	Chequesset Groundwater Flow Cell	14,874	45.3	2.50E+13	4.70E+13	6.90E+13
010900020204	Nauset Groundwater Flow Cell	12,099	38.6	7.40E+12	1.40E+13	2.00E+13
010900020205	Monomoy Groundwater Flow Cell	65,705	191.7	1.60E+14	3.00E+14	4.40E+14
010900020206	Sagamore Groundwater Flow Cell	147,145	427.5	1.10E+14	2.00E+14	3.00E+14

Volume 2
Chapter 2:
Structural BMP
Specifications for
the Massachusetts
Stormwater
Handbook



Subsurface Structures



Description: Subsurface structures are underground systems that capture runoff, and gradually infiltrate it into the groundwater through rock and gravel. There are a number of underground infiltration systems that can be installed to enhance groundwater recharge. The most common types include pre-cast concrete or plastic pits, chambers (manufactured pipes), perforated pipes, and galleys.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	N/A
3 - Recharge	Provides groundwater recharge
4- TSS Removal	80%
5- Higher Pollutant Loading	May be used if 44% of TSS is removed with a pretreatment BMP prior to infiltration. Land uses with the potential to generate runoff with high concentrations of oil and grease require an oil grit separator or equivalent prior to discharge to the infiltration structure. Infiltration must be done in accordance with 314 CMR 5.00.
6 - Discharges near or to Critical Areas	Highly recommended
7 - Redevelopment	Suitable with pretreatment

Advantages/Benefits:

- Provides groundwater recharge
- Reduces downstream flooding
- Preserves the natural water balance of the site
- Can remove other pollutants besides TSS
- Can be installed on properties with limited space
- Useful in stormwater retrofit applications

Disadvantages/Limitations:

- Limited data on field performance
- Susceptible to clogging by sediment
- Potential for mosquito breeding due to standing water if system fails

Pollutant Removal Efficiencies

- | | |
|--|-------------------|
| • Total Suspended Solids (TSS) | 80% |
| • Nutrients (Nitrogen, phosphorus) | Insufficient data |
| • Metals (copper, lead, zinc, cadmium) | Insufficient data |
| • Pathogens (coliform, e coli) | Insufficient data |

Constructed Stormwater Wetlands



Description: Constructed stormwater wetlands are stormwater wetland systems that maximize the removal of pollutants from stormwater runoff through wetland vegetation uptake, retention and settling. Constructed stormwater wetlands temporarily store runoff in shallow pools that support conditions suitable for the growth of wetland plants. Like extended dry detention basins and wet basins, constructed stormwater wetlands must be used with other BMPs, such as sediment forebays. There is also an innovative constructed wetland-the gravel wetland-that acts as a filter. Information on the gravel wetland is presented at the end of this section.

Ability to meet specific standards

Standard	Description
2- Peak Flow	If properly designed, can provide peak flow attenuation.
3- Recharge	Provides no groundwater recharge.
4 -TSS Removal	Provides 80o/o TSS removal when combined with sediment forebay for pretreatment
5- Higher Pollutant Loading	May be used as treatment BM provided basin bottom is lined and sealed
6 - Discharges near or to Critical Areas	Do not use near cold-water fisheries. Highly recommended for use near other critical areas.
7- Redevelopment	Suitable if sufficient space is available.

Advantages/Benefits:

- Relatively low maintenance costs.
- High pollutant removal efficiencies for soluble pollutants and particulates.
- Removes nitrogen, phosphorus, oil and grease
- Enhances the aesthetics of a site and provides recreational benefits.
- Provides wildlife habitat.

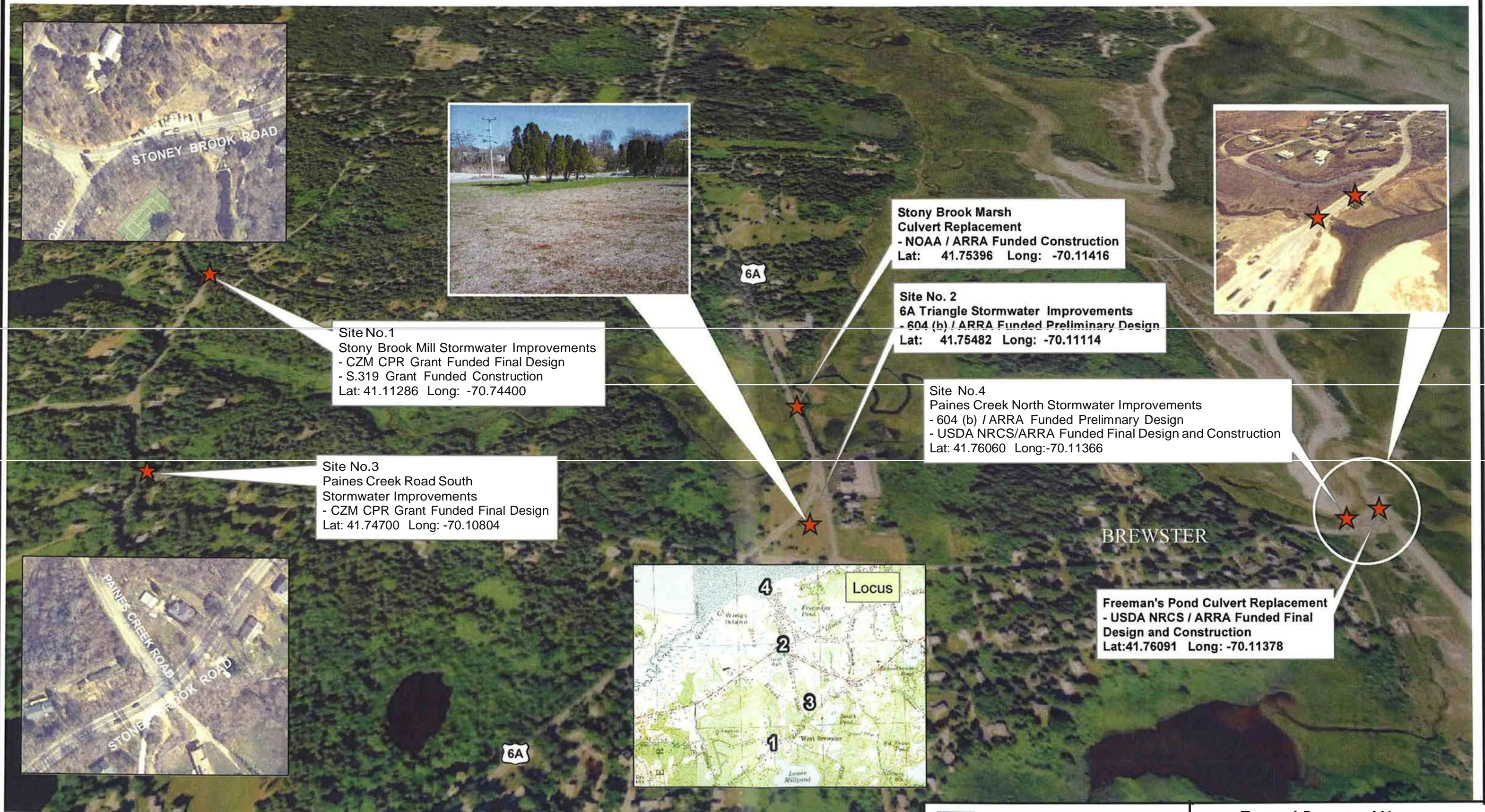
Disadvantages/Limitations:

- Depending upon design, more land requirements than other BMPs.
- Until vegetation is well established, pollutant removal efficiencies may be lower than anticipated.
- Relatively high construction costs compared to other BMPs.
- May be difficult to maintain during extended dry periods
- Does not provide recharge
- Creates potential breeding habitat for mosquitoes
- May present a safety issue for nearby pedestrians
- Can serve as decoy wetlands, intercepting breeding amphibians moving toward vernal pools.

Pollutant Removal Efficiencies

- Total Suspended Solids (TSS) - 80o/o with pretreatment
- Total Nitrogen - 20o/o to 55o/o
- Total Phosphorus - 40o/o to 60o/o
- Metals (copper, lead, zinc, cadmium) - 20% to 85o/o
- Pathogens (coliform, e coli) - Up to 75%

Figures



Data Source: Mass GIS



CLIENTS PEOPLE PERFORMANCE

1545 Ly n n009f1 Road Hynn1\$ MMJ.achus.etts 2071\$ USA
T 1 508 J62 5680 F 1 508 362 5684
E hyamaU@ghd.com W www.ghd.com

PROJECT NO.:

DATE: 01/06/2011

Town of Brewster, MA

Paines Creek and Stony Brook Watershed
Restoration Project Summary

Figure 1



Data Source: Mass GIS

GIS File Location: I:\Jobs\70180\2011 Figures



1545 Iyannough Road, Hyannis Massachusetts 02715 USA
T 1 508 362 5680 F 1 508 362 5684
E hyamail@ghd.com W www.ghd.com

DATE: 05/05/2011

Town of Brewster, MA

Paines Creek and Stony Brook Watershed
Restoration Project Summary Details

Figure 2

:

GHD Inc.

1545 Iyannough Road

Hyannis, Massachusetts 02601

T: 774-470-1630 F: 774-470-1631 E: hyamail@ghd.com

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www.ghd.com



Breakwater Landing

Town of Brewster, MA

Retrofit Concept

1/17/14

Objective: Shoreline erosion has led to loss of dunes and deterioration of the parking lot. In fact, sand deposition has occurred 100 ft into the parking lot. The goal of this retrofit concept is to restore protective dune habitat, provide comparable parking amenities (maintain 59 spaces), improve beach access, and minimize the use and impact of impervious cover.

Description: The proposed retrofit concept consists of three main components as shown in the attached concept plan:



The parking lot at Breakwater Landing is subject to sand deposition and pavement deterioration due to shoreline erosion and rising sea levels.

1. Restoration of coastal habitat

Remove existing pavement (~10,300 sf) within 140 ft of beach. Actively restore, or allow for passive re-establishment, of a majority of this area back to a dune ecosystem. Depending on the Town's objectives, active restoration may include bringing in sand from offsite (or possibly from excavated material at overflow parking—see below), installation of dune fencing, and/or the planting of appropriate vegetation (e.g., American Beach grass, Beach Plum, Bayberry, and Sea-side Goldenrod). A boardwalk or trail connecting the beach and the parking lot should be integrated with the restoration design, as well as a bioretention facility (see below) and interpretive signage. Dune restoration and access path construction are not included in the total cost estimate at this time.

2. Retrofit of existing parking lot

Remove ~2,800 sf of existing pavement along the western edge of the remaining parking lot (~15 ft x 150 ft-strip) and replace with a grass swale that will be used to convey road and parking lot runoff into a bioretention facility. These BMPs should be sized to manage at least 1" of runoff and will be planted with beach-appropriate grasses, shrubs, and ground cover. A curb cut and paved flume will be used at the channel inlet, and a simple spillway would be provided for overflow from the bioretention cell (frequent overflow is unlikely given the sandy soils). Interpretive signage should be posted near the bioretention and trail access. The parking area would be restriped to accommodate at least 29 parking spaces (9 ft x 18 ft) including 3 handicapped spaces and at least two bike racks. The drive aisle width would be between 24 ft and 31 ft (shown at 31 ft); a narrower width would provide more flexibility in the swale design. A location for trash dumpster/restroom facilities could be provided closer to the main entrance.

3. Addition of pervious overflow parking:

Construct an overflow parking lot (~ 8,600 sq ft) in the existing meadow located in the southeast portion of property. This parking area is proposed to be constructed with pervious asphalt and designed for 30 parking stalls (9 ft x 18 ft) with a 24 ft drive aisle width. At an average elevation of 20 ft and native sandy subsoils, only a 18-24 inch- reservoir course would be required below the



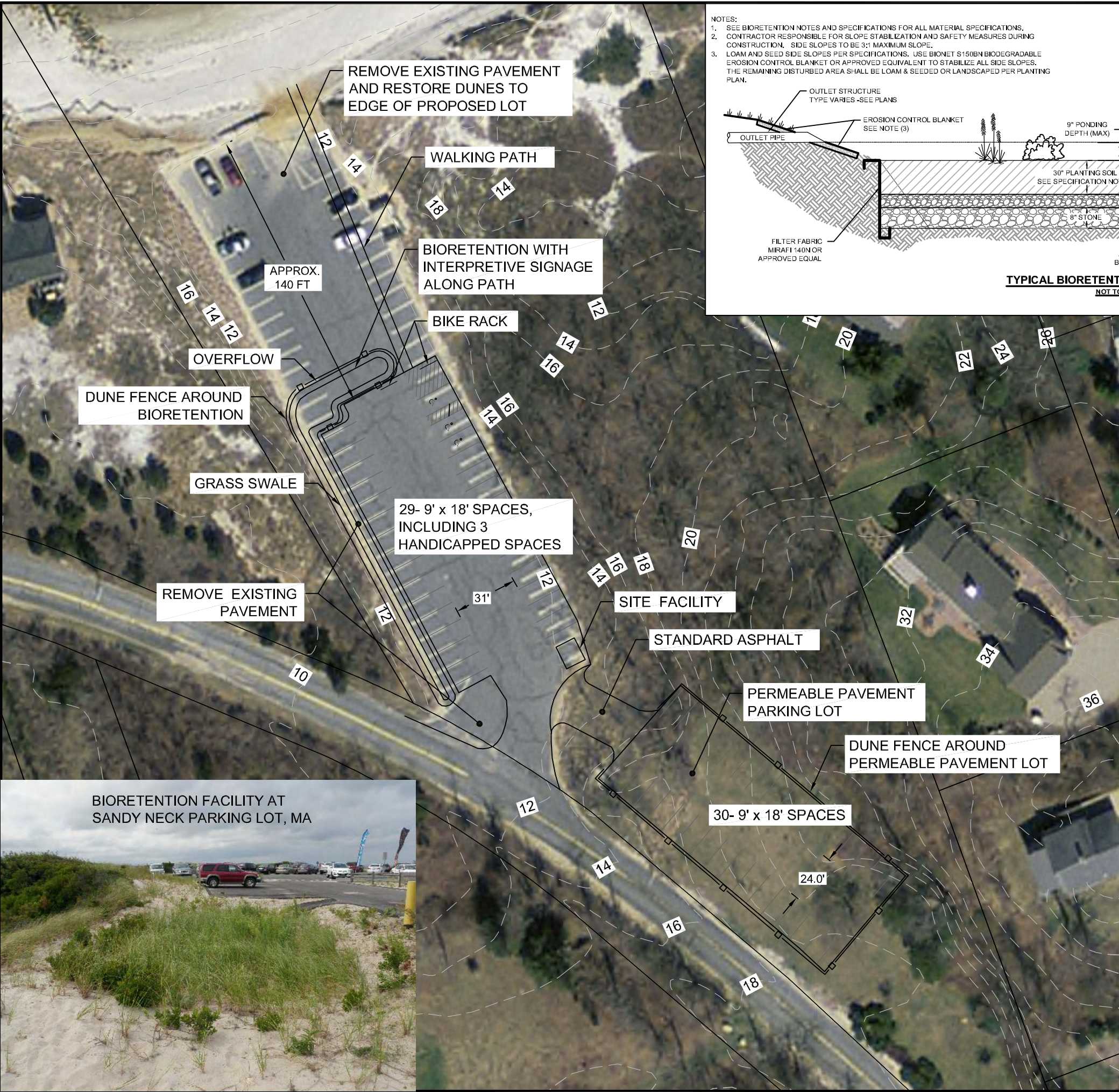
porous asphalt layer (cost estimate assumes 18 inch). Access to the overflow lot will be through a standard asphalt egress off of the existing entrance. Interpretive signage should be posted near the entrance to the overflow parking lot.

Cost Estimate: This is a planning level cost estimate for 10% concept design for the purposes of completing a grant request application. Dune restoration and access path construction are not included in the total cost estimate at this time.

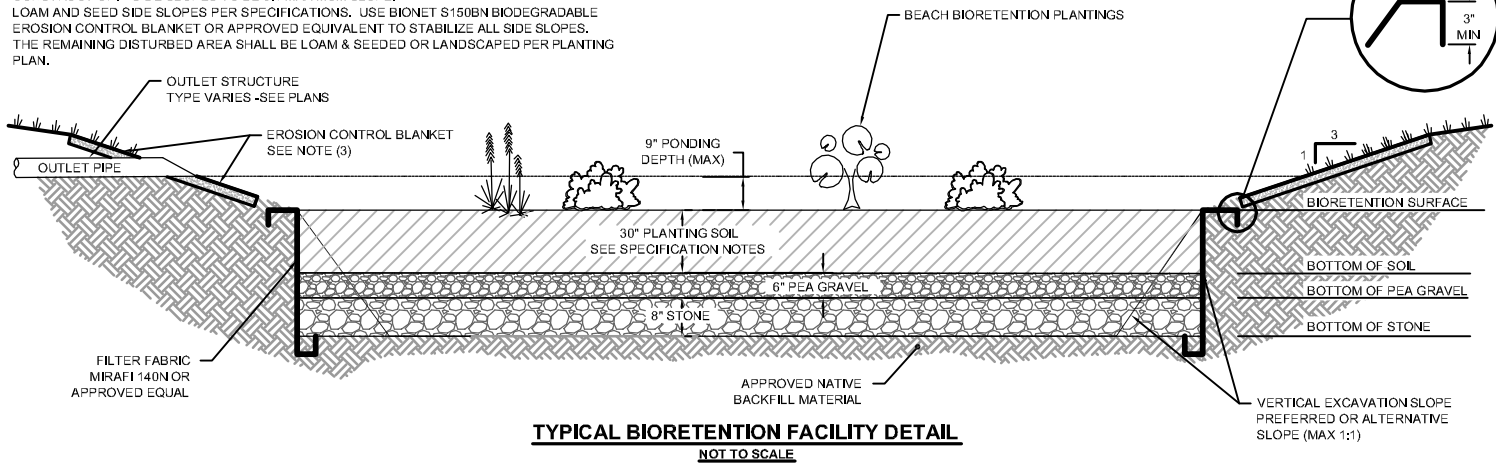
Item	Description	Cost Estimate
Construction Contract	Pavement removal; construction of stormwater BMPs; grading and construction for over flow parking lot and entrance; erosion control; pavement markings; interpretive signage; dune fencing; and bike racks; includes 30% contingency	\$116,000
Engineering and Permitting	25% of construction costs; includes site survey & engineering; assumes extensive permitting due to wetland/beachfront location; certificate of compliance	\$29,000
Construction Admin	~5% of construction costs; including site visits at key aspects of construction; review shop drawings and submittals; respond to RFIs; project closeout and as-built drawing review	\$10,000
Dune Habitat Restoration	Not included due to uncertainties associated with Town preferences (e.g., active restoration of 5 ft dunes which would require renourishment vs allowing natural re-establishment; use of volunteers, etc)	--
Total		\$155,000



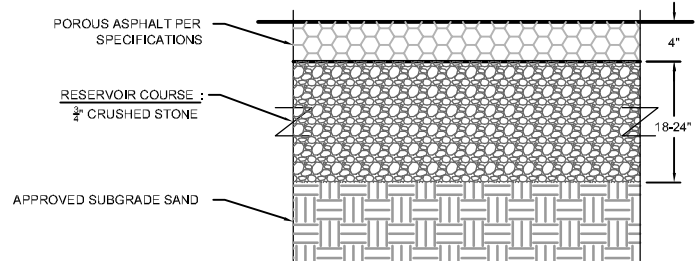
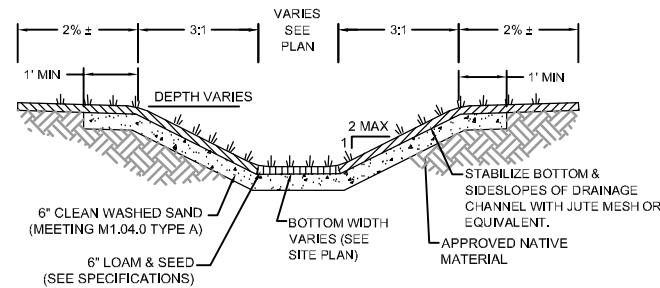
last modified: 01/17/14 printed: 01/17/14 by gc H:\Projects\2011\11109 Brewster Int. Wtr. Res. Mgt Plan\Drawings - 11109\140113_BREAKWATER CONCEPT_11109.dwg



- NOTES:
1. SEE BIORETENTION NOTES AND SPECIFICATIONS FOR ALL MATERIAL SPECIFICATIONS.
 2. CONTRACTOR RESPONSIBLE FOR SLOPE STABILIZATION AND SAFETY MEASURES DURING CONSTRUCTION. SIDE SLOPES TO BE 3:1 MAXIMUM SLOPE.
 3. LOAM AND SEED SIDE SLOPES PER SPECIFICATIONS. USE BIONET S150BN BIODEGRADABLE EROSION CONTROL BLANKET OR APPROVED EQUIVALENT TO STABILIZE ALL SIDE SLOPES. THE REMAINING DISTURBED AREA SHALL BE LOAM & SEEDED OR LANDSCAPED PER PLANTING PLAN.

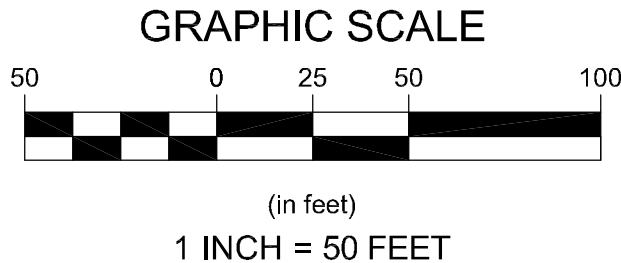


NOTE:
CONTRACTOR SHALL SHAPE CHANNEL IN A PARABOLIC MANNER.



- GENERAL NOTES:
1. SANDY LOAM AND/OR LOAMY SAND TOPSOIL MATERIAL SHALL BE EXCAVATED FROM ALL PAVED AREAS PRIOR TO SUB-BASE INSTALLATION.
 2. SUB-GRADE (EXISTING MATERIAL) SHALL CONSIST OF INERT MATERIAL THAT IS HARD, DURABLE STONE AND/OR COARSE SAND, FREE FROM LOAM AND CLAY TO A DEPTH NOT LESS THAN 4-FT BELOW THE FINISH PAVEMENT SURFACE.
 3. SUBGRADE FILL SHALL BE COMPACTED TO 95% COMPACTION UNLESS OTHERWISE DIRECTED BY THE ENGINEER.
 4. SEE SITE LAYOUT PLAN FOR PAVEMENT WIDTH AND LOCATION.
 5. SEE GRADING PLANS FOR PAVEMENT SLOPE AND CROSS SLOPE.

TYPICAL POROUS ASPHALT CROSS-SECTION
NOT TO SCALE



Revisions		Drawn By		Checked By		Design By		Date		By		Appr.		Revision	
		GSC		GSC		GSC		January, 2014							

Horsley Witten Group, Inc.
Sustainable Environmental Solutions
90 Route 6A
Sandwich, MA 02563
508-833-5600 voice
508-833-3150 fax

**BREAKWATER LANDING
BEACH RESTORATION
BREWSTER, MA**

CONCEPT

Plan Set

Prepared For:
Town of Brewster
2198 Main St. (Route 6A)
Brewster, MA 02631
Phone: (508) 896-3701

Survey & Preliminary Layout Provided By:
Horsley Witten Group
90 Route 6A
Sandwich, MA 02563
Phone: (508) 833-4600
Fax: (508) 833-3150

Registration:

Project Number:

Sheet Number:
1 of 1

Relocation of Breakwater Landing Beach parking area and restoration of beach and dune habitat.

Breakwater Landing is a town-owned 3.4-acre park, including a 59-space parking area and approximately 300-foot beach located on Cape Cod Bay. This is also an important access point to the Brewster Flats for vehicles providing emergency response, and for the public who utilize it for over sand transport of machinery and sand for nourishment projects on private properties within about a 1 mile radius.

Breakwater Landing has been subject to repetitive severe storm damage (see attached photographs). The Town has regularly reconstructed a sacrificial vegetated dune at the north end of the lot after major storm events, plus a sturdy sand fence to capture additional wind-blown sand. The Town and adjacent property to the west are currently reconfiguring this dune. See attached plan from Coastal Engineering.

The objective is to remove the infrastructure at risk from coastal storms and ongoing erosion, provide comparable parking, restore an extensive protective dune habitat behind the beach, improve beach access, minimize impervious cover, and install green stormwater infrastructure (e.g., vegetated bioretention swales) to improve water quality for swimming, shellfishing and habitat. Outputs include removal and relocation of the asphalt parking lot from near the beach to an area less vulnerable to storm damage, restoration of dune habitat, and improved water quality.

Existing pavement would be removed from near the beach at the north, back 140 feet to the south. Additional pavement would be removed from the west side of the remaining parking area adjacent to the coastal dune. Vegetated bioretention swales would be created along the west and north sides of the remaining pavement to capture and treat stormwater. These tasks were scoped out by Horsley Whitten Group, including the required permitting and bidding for the project. See attached plans and estimates for engineering estimates to retreat and relocate parking, plus install vegetated bioretention swales to address stormwater. Estimates for restoration of the former parking area are below.

An 8-foot wide path constructed of articulated concrete blocks (ACBs) would extend north from the remaining pavement to the entrance of the beach. This would allow continued vehicle access to the beach while not generating stormwater. These ACBs have proven to be very resilient to storm events. As erosion affects the beach, segments of the ACBs could be removed from the north end.

A second seasonal boardwalk would be placed directly adjacent to the ACBs for foot traffic and to provide handicap access to the beach area.

A new area of permeable pavement would be constructed, located south of the existing pavement and at a higher elevation. This would replace parking that would be lost by the removal of the parking area closest to the beach.

Access path from relocated parking area to beach

1. Costs for ACBs are estimated from a similar project recently completed in a neighboring town (Cotchpicut Landing in Chatham, MA). 160 feet of ACBs (10 8x16 foot mats) including 10% contingency: \$19,593.75
2. Cost for seasonal handicap accessible walkway to beach (SuperDeck or equivalent)
160 feet long, 5 foot wide @ \$15.84/square foot delivered (includes 10% contingency): \$12,672.00

Dune restoration and plantings in area of removed pavement

The Town is currently working with the neighbor to the west of the landing on creating a vegetated dune and sturdy sand fence just north of the existing pavement (plan attached). We anticipate this to be completed in the spring of 2014.

For this restoration project, we anticipate the northern most 70 feet of former parking area will be filled with screened sand compatible with adjacent dune deposits. This area will be elevated approximately 4 feet above the elevation of the existing pavement, which would be similar to the elevation on the property to the west. South of there we will keep the back dune area at a slightly higher elevation than the existing parking lot. It is anticipated that the dunes will migrate south with prevailing winds.

The area is approximately 125 feet by 67 feet, or 8,375 square feet. The volume of sand to be placed is approximately 5' deep for one half and 2' deep for the second half, or a total volume of 29,375 cubic feet, or 1090 cubic yards. A cubic yard of sand delivered and placed is approximately \$15, so the cost for sand is \$16,350. With a 10% contingency we have a budget of \$17,985.

Beach grass plugs will be planted in the restored area. Beach grass will be planted in late fall and through the winter up until mid-April. Dormant culms will be planted 8" deep, with two to three stems per hole, spaced 12" to 18" apart. The Town will coordinate the beach grass plantings using youth volunteers. In the back dune area, 150 1-gallon beach plum and 50 1-gallon bayberry plants will be included in the beach grass planting area.

Plants cost: \$6000 for shrubs including planting. Beach grass plugs \$1/square foot plus planting costs (to be completed by Town volunteers). Town staff and volunteers will weekly water the shrubs as needed through one growing season to ensure viability.

Summary of dune restoration costs:

Access paths through restored area:

ACBs	\$19,593.75
Accessible decking	\$12,672.00

Dune restoration:

Screened sand	\$17,985.00
Shrubs	\$ 6,000.00
Beach grass	\$ 8,375.00

Subtotal, restoration of former parking area: **\$64,625.75**

Subtotal, parking lot relocation/green stormwater (see attached): **\$155,000**

Total project budget: \$219,625.75



Breakwater Beach January 3, 2010.



Rebuilding/replacing the artificial dune at Breakwater in January 2010.



Breakwater Beach on March 3, 2010. 2010 winter storms removed the remnants of the dune at the north end of the parking lot, and caused the parking lot to be undermined. In January 2010, sand was placed to provide additional protection for the remainder of the winter. The sacrificial dune was destroyed that winter, and additional parking area is lost. The parking lot elevation is low, and unless protected, we may expect additional loss of pavement each year, in part due to the lack of sediment transport from further west (revetments and groins).



Stormwater currently collects in the northwest corner of the lot, and causes erosion of the dune as it moves north onto the beach. At times this forms a deep very large puddle, and forces a hole through the dune over time. Grant proposal would eliminate the direct stormwater discharge onto the beach, reduce the volume of stormwater generated, and treat the stormwater through natural bio swales or porous pavement.



Dune reconstruction at Breakwater with Brandeis University student volunteers, April 2011.



Coastal Engineering Co., Inc. © 2013



Statement of Litigation

Instructions: Save this document on your computer and complete. The final narrative should not exceed two (2) pages; do not delete the text provided below. Once complete, upload this document into the on-line application as instructed.

Litigation: In the space provided below, state any litigation (including bankruptcies) involving your organization and either a federal, state, or local government agency as parties. This includes anticipated litigation, pending litigation, or litigation completed within the past twelve months. Federal, state, and local government applicants are not required to complete this section. If your organization is not involved in any litigation, please state below.

The Town of Brewster, Massachusetts is a local government and is not required to complete this section.



Town of Brewster

BREWSTER, MASSACHUSETTS 02631-1898

(508) 896-4506 – Fax (508) 896-8089
cwilliams@town.brewster.ma.us

OFFICE OF:
COLETTE M. WILLIAMS, CMC/CMMC
TOWN CLERK
JUSTICE OF THE PEACE
NOTARY

To Whom It May Concern:

This letter is to certify that at the Annual Town Meeting, held, Monday, May 6th, 2013 with a quorum being present the following article was adopted unanimously:

ACCEPTANCE OF GRANT PROCEEDS

ARTICLE NO. 17: To see if the Town will vote to authorize the Board of Selectmen to apply for and accept any and all grants from private entities, the Federal Government or the Commonwealth of Massachusetts and to expend those funds for the purposes for which said grants are authorized, or to take any other action relative thereon.

(Majority Vote Required)

(Board of Selectmen)

MOTION: I move that the town vote to approve article no. 17 as printed in the warrant.

ACTION: ADOPTED UNANIMOUSLY

A True Copy Attest:

Colette M. Williams, CMC/CMMC
Town Clerk
Brewster, MA



Town of Brewster

2198 Main Street
Brewster, MA 02631-1898
Phone: (508) 896-3701
Fax: (508) 896-8089

Office of:

Board of Selectmen
Town Administrator

January 27, 2014

David O'Neill, Vice President, Conservation Programs
National Fish and Wildlife Foundation
1133 Fifteenth Street, NW Suite 1100
Washington, DC 20005

Re: Letter of support for the Town of Brewster's proposal *Building Coastal Resilience* to the National Fish and Wildlife Federation RFR for Hurricane Sandy Coastal Resiliency Competitive Grants Program

Dear Mr. O'Neill,

The Town of Brewster is pleased to submit its proposal- Building Coastal Resilience- to the National Fish and Wildlife Foundation to support the Town's efforts to plan for coastal change and to implement specific projects that increase the town's resiliency and restore the ecosystem functions of our coastal beaches, dunes and marshes. Brewster has nearly 6 miles of coast on Cape Cod Bay that takes the brunt of winter storms and hurricanes. The combination of being open to northeast and northwest winds and tidal ranges that can reach over 10 feet at high tide makes Brewster especially vulnerable to coastal storms and storm surge.

In the past five years we have been pro-active in retreating from one public beach parking lot that sustained repeated storm damage. In addition Brewster worked with a number of partners and secured federal funding for improving tidal flow in the Paines Creek/Stony Brook estuary that supports one of Massachusetts' significant herring runs. We have other public beach parking areas that have been storm-damaged and, because of their coastal location, are interfering with the natural functioning of the beach- dune- wetland complex at these locations.

Brewster's proposal lays out a more comprehensive approach to assessment, planning, design and implementation of a coastal resiliency program. We recognize the importance of integrating coastal science, technical information, public participation and sound design in a plan that will be the foundation for future Town actions. This work will be led by the Town's Department of Natural Resources and will involve the Conservation Commission, the Planning Department, the Department of Public Works and our Fire Department as the Town's Emergency Management Coordinator.

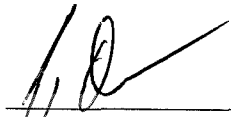
The Board of Selectmen are appointing a Coastal Committee made up of citizen volunteers that will work with the Brewster's Department of Natural Resources (DNR) in reviewing drafts of the plan and developing recommendations on short- and long-term actions. The DNR formed a volunteers group - FLATS: Friends of Lands, Aquatics, Trails and Shellfish- with over 100 members from the community; young and old, men and women, boy scouts and military veterans- who assist DNR on a

variety of coastal projects. Brewster will also work with its coastal neighbors, Dennis and Orleans, as the sediment that maintains our beaches is shared with both towns.

As the board responsible for setting town policies and priorities, the Board of Selectmen believes the work laid out in this proposal is critical to our future coastal management decisions. Brewster has demonstrated experience in managed retreat and coastal restoration. I urge you to support this important proposal that links ecosystem health with increased resiliency.

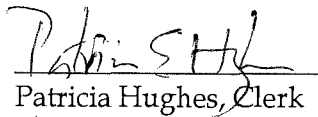
Sincerely,

Brewster Board of Selectmen

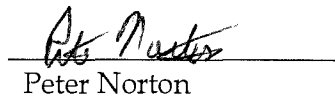


John Dickson, Chairman

James Foley, Vice-Chairman



Patricia Hughes, Clerk



Peter Norton



Benjamin deRuyter

Other Documents: Table of Contents

1. Brewster Grants/Leveraging
2. Citations and References for Sediment Budget
3. Center for Coastal Study Sediment Tasks
4. 2010 Concept Plans for Parking Improvements for Crosby Beach and Mansion and Linnell Landing, Brewster
5. Factsheet on USGS Modeling of Sea Level Rise Impacts to Groundwater on Cape Cod
6. Key Steps in Developing the Town-wide Brewster Coastal Resiliency Plan and Estimated Budget
7. Factsheet on Massachusetts Audubon Society Oyster Reef
8. Newspaper Article on Paines Creek Parking Lot Retreat
10. Interns/volunteers
11. Collaboration and Partnerships
12. Environmental Monitoring of Beach and Dune Restoration, and Oyster Reef and Salt Marsh Protection Monitoring Plan

Brewster grants for restoration projects			
Grant or Funding Source	\$	Purpose	Benefits
NOAA-Coastal-Restoration/ARRA grant	\$1,647,600	Stony Brook salt marsh and fish passage restoration, also Lower Mill Pond dam and fish passage improvement, and Freeman's Pond salt marsh restoration permitting	Restore total of 41 acres of salt marsh (20 at Stony Brook, 21 at Freemans Pond), improve 3000' of diadromous fish run to 386 acres of herring spawning
Gulf of Maine Council / NOAA Habitat Restoration grant	\$58,600	Stony Brook salt marsh restoration feasibility study	Part of above
Woods Hole Group corporate donation	\$15,000	Corporate donation for feasibility study modeling, Stony Brook salt marsh	Part of above
CZM Non-point source assessment	\$19,150	stormwater assessment and prioritization for watershed	Stony Brook watershed
CZM Coastal Pollutant Remediation	\$20,142	Design & permitting of stormwater BMPs, south of 6A	Protects water quality and herring run to 386 acres of spawning habitat in five ponds; also protects and improves 8 acres of shellfish beds in Paines Creek
MA DEP 319 nonpoint source program	\$346,800	Stormwater construction, Stony Brook Road near Mill	Protects water quality and herring run to 386 acres of spawning habitat in five ponds
DEP 604(b) ARRA	\$58,000	Design and permitting of stormwater BMPs along Stony Brook Road, north of 6A (incl. runoff from Lower Road?)	Protects and improves condition of 8 acres of shellfish beds
Cape Cod Water Resources Restoration Project (CCWRRP)-ARRA	\$311,250	Freeman's Pond salt marsh restoration construction	Part of above
Cape Cod Water Resources Restoration Project (CCWRRP)-ARRA	\$213,000	Paines Creek Beach stormwater improvements: engineering design & construction	Protects and improves condition of 8 acres of shellfish beds
Cape Cod Water Resources Restoration Project (CCWRRP)-ARRA	\$41,250	Saints Landing stormwater improvements: construction	Protects 10,667 acres of shellfish beds
Private foundation grants to APCC	\$60,000	Monitoring herring run, salt marshes, and coastal erosion in Brewster	Coastal habitat in Brewster
Mass Bays Program, in-kind match from Regional Coordinator	\$76,000	Assist Town with project development, grant-writing, project management, coordination & outreach.	Coastal habitat in Brewster
Volunteer labor for monitoring, in-kind match	\$57,603	Monitoring of salt marsh, herring run, each year for 7 years.	Collection of monitoring data; builds citizen stewardship
Volunteer labor to maintain herring runs, in-kind match	\$57,603	Volunteer labor to maintain herring run, each year for 7 years	Stony Brook, other runs
Town of Brewster funding for Stony Brook, Freeman's Pond and Lower Mill Pond:		Supported these restoration projects	
Total:	\$2,981,998		
Other leveraging:			
Mass Bays Program Research & Planning Grant to Wellfleet Audubon Sanctuary, Oyster Reef Monitoring Project, 2011	\$19,529	Grant enabled monitoring and testing of different oyster reef construction methods and monitoring for biodiversity and oyster success. Method is transferrable to Brewster.	
Mass Bays Program Research & Planning Grant to Provincetown Center for Coastal Studies, Sediment Budget Project for Truro and Wellfleet, 2011	\$22,119	Grant enabled PCCS to conduct modeling study of coastal sediment budget for nearby towns of Truro and Wellfleet. Method is transferrable to Brewster.	
Town of Brewster, Town Meeting	\$1,500,000	Town meeting in 2007 approved town funds to purchase 40 acres of open space for conservation	Stony Brook watershed resources (herring run, salt marsh, wetlands, rare species habitat)
Brewster Conservation Trust	\$50,000	Private land trust in 2007 raised \$50000 to purchase adjacent 10 acres of open space for conservation	Same as above
Town of Brewster	\$700,000	Integrated Water Resource Plan	Plan to integrate management of drinking water, stormwater and wastewater to protect water resources and the environment.
Total, other leveraging:	\$2,291,648		Doesn't include all applicable leveraging
Total, grants and other leveraging:	\$5,273,646		

References and Citations for Sediment Budget

Berman, Greg, 2011. Longshore Sediment Transport, Cape Cod, Massachusetts, April 2011. Woods Hole Oceanographic Institution and Barnstable County Extension. 48 pp.

Giese, G.S., M.B. Adams, S.S. Rogers, S.L. Dingman, M.Borrelli and T.L.Smith 2011. *Coastal Sediment Transport on Outer Cape Cod, Massachusetts*. In P. Wang, J.D. Rosati and T. M. Roberts (eds.) Coastal Sediments '11, American Society of Civil Engineers, v. 3, p. 2353-2356.

Giese, G.S., Borrelli, M., Mague, S.T., Hughes, P. (2012). *Evaluating Century-Scale Coastal Change: A Pilot Project for the Beach Point Area in Truro and Provincetown, MA*. A report prepared by the Provincetown Center for Coastal Studies for the Island Foundation. April 2012. 19 p.

Mague, S.T. (2012) *Retracing the Past: Recovering 19th Century Benchmarks to Measure Shoreline Change Along the Outer Shore of Cape Cod, Massachusetts*. Cartography and Geographic Information Science, Vol. 39, No. 1, pp. 30-47.

Sediment Budget Analysis – Sesuit Harbor, Dennis, Massachusetts to Namskaket Creek, Orleans, Massachusetts

Center for Coastal Studies

In order to better understand sedimentation processes along the Brewster shore and address pressing coastal management issues, the Center for Coastal Studies (CCS) will quantify sediment movement for the segment of the Cape Cod Bay shoreline extending from Sesuit Harbor in Dennis east along the Brewster coast to Namskaket Creek in Orleans (the study area). Namskaket is known to be an area of sediment deposition, based on the littoral cell description by Berman (2011). This work will characterize the natural dynamics of this system, providing an assessment of sediment transport and sediment budget calculations for approximately 11.3 km (7 miles) of shoreline. To quantify the longshore sediment transport rates, sediment sources and sinks, and littoral cell boundaries, a simple geomorphic model (Giese, et al., 2011), based on the conservation of mass, coastal wave mechanics, and the coastal morphodynamic concept of transport within littoral cells, will be applied as demonstrated in previous CCS work (Giese, et al., 2012, Giese, et al., 2013, Giese, et al., 2014).

Task 1: Development of Historical Geospatial Data

As described in Task 2 below, the hydrographic work of the United States Coast & Geodetic Survey (USC&GS) performed during 1933 and 1934, supplemented with historical topographic information of the relatively small land areas subject to marine and coastal processes will be used to compile an historical surface model for quantitative comparison with a contemporary surface model derived from LiDAR. The 1930s USC&GS hydrographic work is related horizontally to the North American Datum of 1927 (NAD27) and vertically to local mean low water (MLW). Those historical data will be translated into contemporary horizontal and vertical reference systems. As demonstrated on related projects, an accurate translation from NAD27 to the contemporary North American Datum of 1983 (NAD83) is well documented (Giese et al, 2010; Giese et al, 2009). Vertical translations from a local MLW datum to a contemporary geodetic datum such as the North American Vertical Datum of 1988 (NAVD88) are geographically-specific, however, requiring the acquisition of historical benchmark information and field work to determine reliable conversions. To ensure accurate comparisons of elevation data, recent methodology developed and documented as part of PCCS's Marindin project, will be utilized to relate historical soundings and elevations to a contemporary vertical datum (Mague, 2012). The resulting product will be a comprehensive data set of historical geospatial data related horizontally to NAD83 and vertically to NAVD88.

Task 2: Historical Surface Model Development

The datum-translated historical data developed in Task 1 will be used to create a 3-dimensional surface of the study area for comparison with the contemporary surface created in Task 3. To create this surface, the translated longitude, latitude and elevation (x,y,z) data from each point will be extracted and used to create a digital database of all historical point information. Data from these points will be used to create a point shapefile within the ARCGIS v10.0 software suite and these points will then be converted into a Triangulated Irregular Network (TIN) using the 3-D analyst extension with ARCGIS to generate a real-world surface. Based on the translations developed in Task 1, the surface will relate horizontally to NAD83, meters and vertically to NAVD88, meters.

Task 3: Contemporary Surface Model Development

A contemporary surface model of the study area will be produced using bathymetric data from PCCS's Nearshore Seafloor Mapping Project and bathymetric and topographic LiDAR data (2011) from the U.S. Army Corps of Engineers. As with the historical surface, the contemporary surface will relate horizontally to NAD83, meters and vertically to NAVD88, meters. Since an approximately 6 square mile offshore area north of the Namskaket area is not covered by bathymetric LiDAR, CCS will use its survey vessel the R/V *Marindin*, equipped with seafloor mapping equipment, to acquire the necessary bathymetric data along appropriate transects.

Task 4: Transect Construction

Based on the surface models developed in Tasks 2 and 3, transects will be constructed along the 11.3 km shoreline comprising the study area. As the initial step in this task, a baseline will be defined to which all transects will be related. As with previous studies, to minimize potential influences of anthropocentric and other non-related processes on study results, the baseline will be established at the estimated landward limit of the area contributing sediment to marine and coastal transport. Where possible the baseline location will include features common to both historical and contemporary surfaces (e.g., street intersections, railroad right of way) to facilitate field checks of elevations and verification of the surface models. After a suitable baseline has been developed, an estimated 75 shore perpendicular transects will be constructed at approximately 150 meter intervals and extend offshore about a mile to the approximate 6 m depth. Due to the extensive nature of the tidal flats, actual transect lengths will be adjusted during the initial phases of the analysis. Once transect locations have been defined, comparative profiles (*x, y, and z data*) for the historical and contemporary surfaces will be constructed for each transect and exported as EXCEL spreadsheets to form the basis for volumetric analysis in Task 5.

Task 5: Volumetric Analysis

Applying the geomorphic model and using the spreadsheet information generated in Task 4, MATLAB software will be used to compare the 1933/34 and contemporary profiles to determine the area between them. Further analysis will provide estimates of the annual change in sediment volume per unit distance along the shore, and the annual change in net longshore sediment transport (longshore flux) at each transect location. The distribution of the change in longshore flux along the shoreline will permit the location of the "null points" (points of no net longshore flux) within the zone of active sediment transport. From this information, an estimate will be made of the overall sediment budget (including the location of sources and sinks), the net direction of longshore sediment transport, and the volume-rate of that transport.

Task 6: Report and Recommendations

A final a project report will be prepared describing the methodology used and the quantitative results of this study. The report will include a discussion of shoreline change over the last 80 years for the study area, identify high erosion areas and sources and sinks of sediment and provide recommendations for coastal managers responsible for developing responses to climate change and sea level rise.

Labor Costs:	Hr. rate	Hours	
Senior Scientist	88.27	204	18,006.92
Associate Scientist	66.20	76	5,031.35
Adjunct Scientist II	57.38	288	16,524.00
Research Associate II	44.13	32	1,412.31
Intern	22.07	280	6,178.85

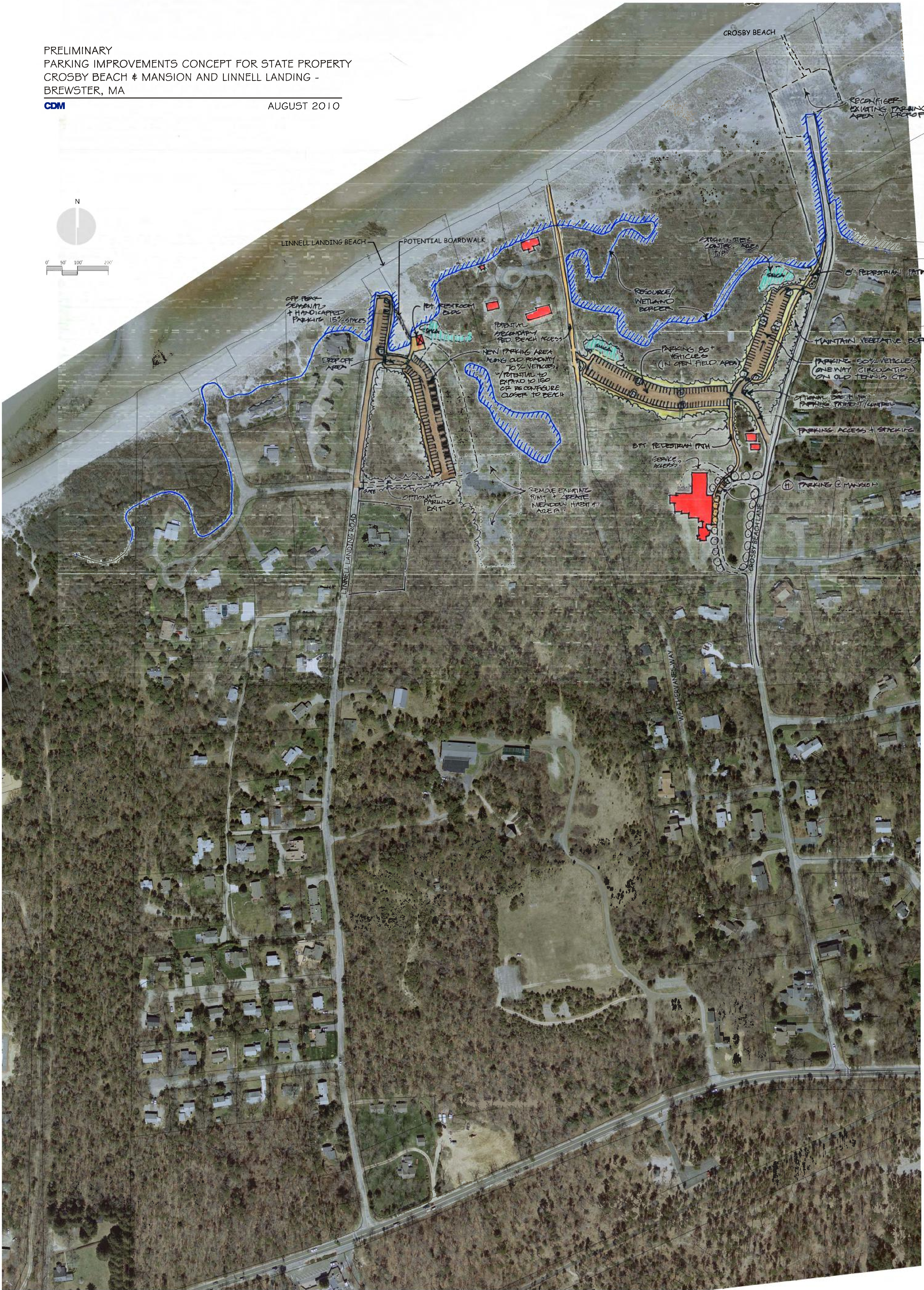
Total Labor: **\$ 47,153.42**

Estimated Total Project Cost: **\$52,660**

PRELIMINARY
PARKING IMPROVEMENTS CONCEPT FOR STATE PROPERTY
CROSBY BEACH & MANSION AND LINNELL LANDING -
BREWSTER, MA

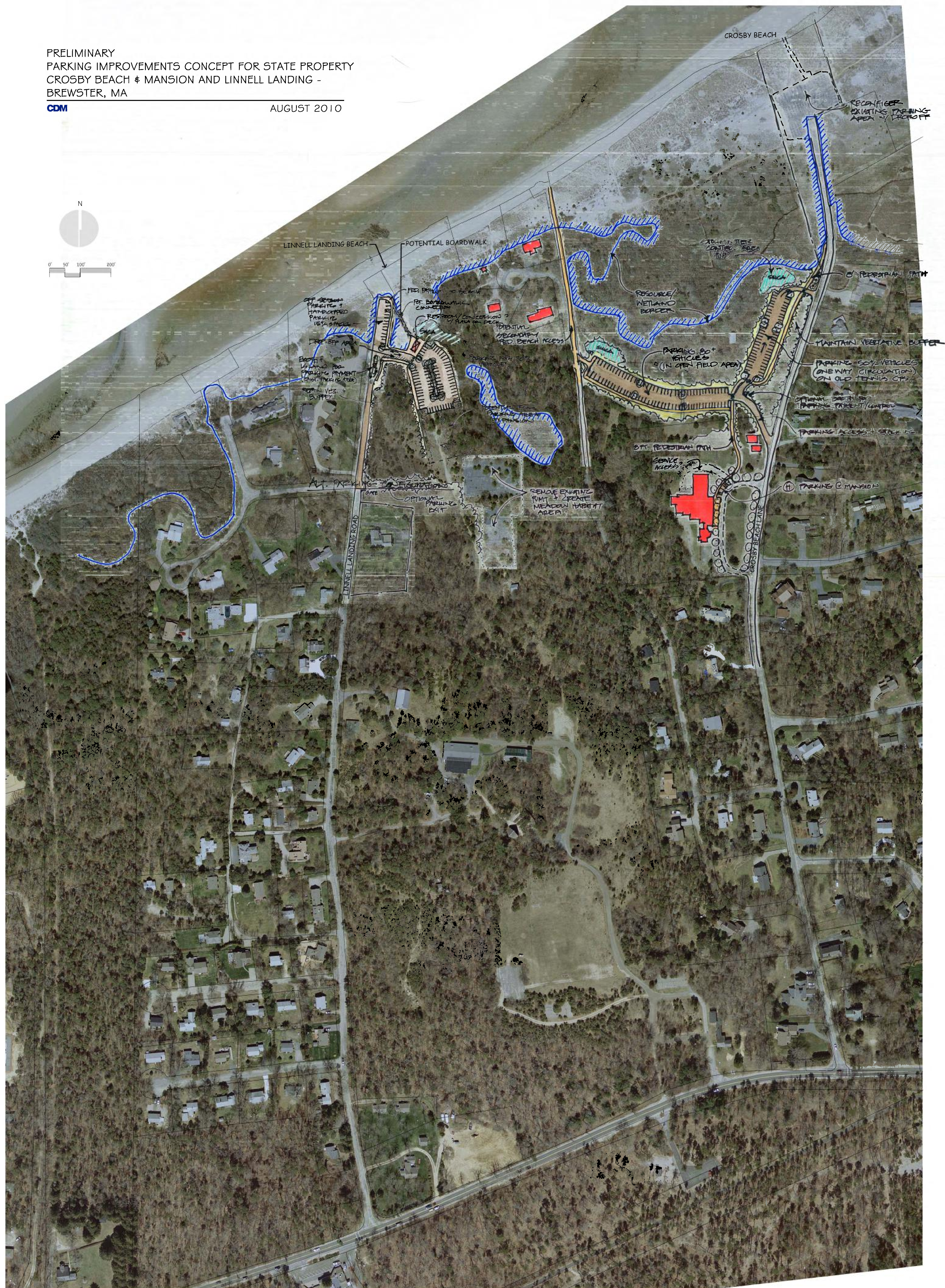
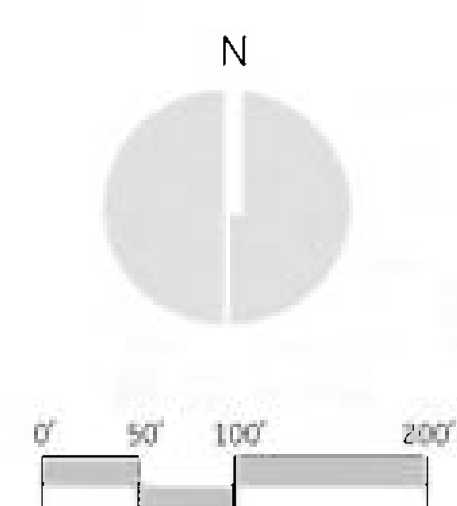
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AUGUST 2010



CDM

AUGUST 2010



Evaluating the effects of sea level rise on Massachusetts coastal aquifers: a Cape Cod pilot study

Strong scientific evidence indicates that sea level in the Northeast has been rising and will continue to rise; recent estimates point to sea level rising three to four times faster than the global rate ^(1, 2). Sea level rise will likely cause impacts such as increased area of land under water, increased coastal flooding and erosion, increased storm damage, and changes in beaches, dunes, salt marshes, inlets and other coastal landforms ^(3a, 3b).

On Cape Cod, we also need to evaluate the effect of sea level rise on the water table and our aquifer. How would rising sea level affect the water table? Cape Cod is composed of highly permeable sand and gravel deposits. Permeable means that water can easily pass through these deposits. Rain and melting snow percolate down through permeable soils to recharge the water table at the top of the underlying fresh water aquifer. While the height of the water table depends on recharge, the lowest point of the water table is at sea level (**Figure 1**).

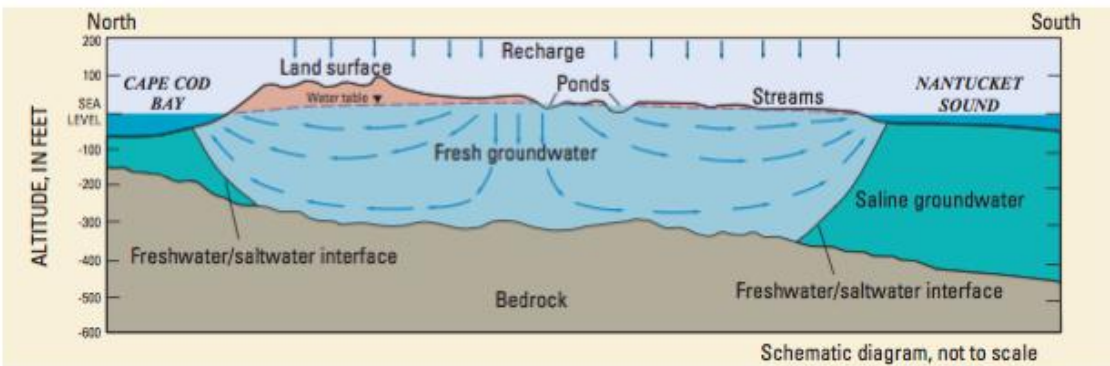


Figure 1. Cross section of the mid-Cape region from Cape Cod Bay to Nantucket Sound that shows how groundwater flows through the aquifer from land surface to the shore ⁽⁴⁾.

In areas like Cape Cod that are surrounded by the sea, changes in sea level will affect the height of the water table. In other words, as sea level rises, so will the water table. This is a concern in areas where the water table is already close to the surface (**Figure 2**). Modest changes in water table elevation can result in subsurface flooding that could impact septic systems, infrastructure and property. Water resources, wetlands and ecosystems could also be affected.



Figure 2. New Silver Beach area of Falmouth at high tide. This area was sewered in order to improve water quality. Before sewerage, many septic systems were in contact with high groundwater which allowed wastewater to leach into coastal waters.

APCC is working with U.S. Geological Survey (USGS) hydrologists to conduct a study that will analyze the effects of sea level rise on groundwater flow in the mid-Cape region, the most densely populated area of the Cape. The proposed mid-Cape study will build on previous USGS models of the lower Cape aquifer's response to rising sea level and studies of the mid-Cape aquifer (4, 5, 6). These models indicated that rising sea level will cause the water table to rise in areas away from streams, while in other areas drained by groundwater-fed streams the water table could drain faster due to increased streamflow caused by the higher water table, resulting in rejuvenated streams. Summarizing the lower Cape studies, rising sea level can impact coastal aquifers by causing changes in: 1) height of the water table and depth to groundwater, 2) stream base flow, and 3) position of the freshwater/saltwater interface.

Such changes in hydrology could have important implications for management of wastewater, water and natural resources and for protection of public health and the environment. The mid-Cape study will provide information needed for science-based planning to address these issues. Products will include GIS maps of regional changes in water table elevations, cross-sections showing changes in the saltwater/freshwater interface, and tables of stream-flow changes for different sea level rise scenarios. We need to understand how sea level rise could affect our aquifer in order to plan for adapting to climate change.

Project team members include USGS, APCC, Cape Cod Commission, Mass Bays Program, and Barnstable County Coastal Resources Committee. Support is provided by the Massachusetts Environmental Trust, The Nature Conservancy, grants, and APCC dues. Additional funding will be needed. For more information, contact Ed Dewitt or Jo Ann Muramoto at (508) 362-4226.

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- (1) Sallenger, A.H., Jr., Doran, K.S., and Howd, P.A. 2012. Hotspot of accelerated sea-level rise on the Atlantic coast of North America. *Nature Climate Change*, online June 24, 2012.
- (2) Gade, M. October 2012. "Sea level rise accelerating on U.S. Atlantic coast"
<http://soundwaves.usgs.gov/2012/10/research.html> .
- (3a) Frumhoff, P.C., J.J. McCarthy, J.M. Melillo, S.C. Moser, and D.J. Wuebbles. 2007. *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions*. Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists (UCS). <http://www.northeastclimateimpacts.org/>
- (3b) Massachusetts Office of Coastal Zone Management, StormSmart Coasts website at <http://www.mass.gov/czm/stormsmart/> .
- (4) Masterson, J.P. and Walter, D.A. 2009. Hydrogeology and groundwater resources of the coastal aquifers of Southeastern Massachusetts. USGS Circular 1338. <http://pubs.usgs.gov/circ/circ1338/>.
- (5) Masterson, J.P. 2004. Simulated interaction between freshwater and saltwater and effects of groundwater pumping and sea-level change, Lower Cape Cod aquifer system, Massachusetts. USGS Scientific Investigations Report 2004-5014. <http://pubs.usgs.gov/sir/2004/5014/> .
- (6) Masterson, J.P., and Portnoy, J.W. 2005. Potential changes in ground-water flow and their effects on the ecology and water resources of the Cape Cod National Seashore, Massachusetts: USGS General Information Product 13. <http://pubs.usgs.gov/gip/2005/13/> .

Key Steps to Developing Brewster's Coastal Resiliency Plan

A. Natural Systems

- Resource Inventory and Assessment, and Integration of Sediment Budget
- Identification of Potential Restoration Sites
- Resource Mapping at identified Restoration Sites
- Prioritization of Future Restoration Sites
- Development of Implementation Plan

B. Built Public and Private Infrastructure

- Analyze changes from current and previous federal floodplain maps
- Assess information from Massachusetts' Shoreline Change Mapping Program
- Utilize sea level rise mapping/visualization tools, including data from the Cape Cod Commission
- Analyze groundwater impacts from sea level rise
- Repetitive infrastructure loss analysis

C. Resiliency Plan

- Public access element
- Off site transportation element
- Managed retreat plan
- Regulatory and land use planning changes, i.e. stormwater management, development setbacks

D. On-going Public Outreach

- Public workshops, webinars, mailings, e-blasts, website postings
- Interpretive signs at four coastal implementation projects

Cost Estimate - Brewster Coastal Adaptation Plan

a	Sediment Transport/Sediment Budget		
	Coordination/reporting role related to CCS analysis		\$5,000
		SUBTOTAL	\$5,000
b	Natural Systems Restoration		
	Shoreline/Resource Assessment		\$12,500
	Identification of Restoration Sites Not Currently Considered		\$5,000
	Initial Resource Mapping at ID'd Restoration Sites		\$7,500
	Prioritization of Future Restoration Sites		\$10,000
	Development of Implementation Plan		\$7,500
	Coordination with Town's CIP		\$5,000
	Open Space/Coastal Retreat Planning		\$5,000
		SUBTOTAL	\$52,500
c	Risks to infrastructure and homes		
	floodplain mapping - analyzing changes, not challenging mapping		\$10,000
	shoreline change mapping		\$7,500
	Sea level rise mapping/visualization		\$12,000
	GW impacts from sea level rise (with APCC)		\$3,000
	Repetitive infrastructure loss analysis		\$5,000
	Outreach program (meetings, webinars, mailers, e-blasts)		\$20,000
		SUBTOTAL	\$57,500
d	Resiliancy Plan		
	LCP updates		\$15,000
	Regulatory Updates (stormwater updates in progress already)		\$20,000
	Managed retreat plan		\$15,000
	Interpretive signs (\$2500/sign)		\$10,000
	Off site transportation plan		\$12,500
	Incorporate GW sea level rise impacts (BOH regs in sensitive areas?)		\$5,000
		SUBTOTAL	\$77,500
		TOTAL	\$192,500



Energy and Environmental Affairs

[Home](#) > [Agencies](#) > [Mass Bays Program](#) > [Oyster reef restoration and monitoring](#)


Oyster reef restoration and monitoring in Wellfleet

Based on historical records from the early 1900s the populations of the Eastern Oyster (*Crassostrea virginica*) in Wellfleet, MA have diminished drastically over the past 100 years. As a reef-forming keystone species which serves as refuge for a variety of marine organisms, helps reduce shoreline erosion, improves water quality through biofiltration, and plays a role in nutrient cycling in estuaries, this decline has had impacts on the overall diversity and abundance of marine life as well as the water quality in Wellfleet Harbor.

Up until an oyster reef restoration project was begun in 2008 by the [Massachusetts Audubon Society](#) (Mass Audubon) in partnership with the National Oceanographic and Atmospheric Administration, The Nature Conservancy, and the Town of Wellfleet, no shellfish habitat restoration projects of this kind had been undertaken in Massachusetts and Cape Cod Bays. In 2011, this three year experimental oyster restoration in Wellfleet was completed, resulting in a population between 60,000 to 250,000 oysters.

Results indicated oyster castles to be the best substrate for oyster restoration, maintaining their structural integrity over time and showing a net increase in their oyster population each year. In addition it was noted that invertebrate abundance and diversity, as well as the incidence of shorebirds, have increased at the project site relative to control sites. American Oystercatchers, a species of management concern in Massachusetts, now regularly feed on blue mussels growing at the site as a result of this project. Preliminary data indicate that several fish species, including juvenile tautog and cunner, killifish, and even squid may be preferentially using the reef relative to adjacent control areas.

The results of this project have also shed some light on ways to facilitate the permitting process and a number of recommendations were developed including that the State provides protection for future shellfish restorations by creating no-harvest "spawning sanctuaries".

Details of the experimental process, data collected, and management recommendations are provided in the final report: [Oyster Reef Restoration and Monitoring in Wellfleet, MA. Massachusetts Audubon Society. 2011.](#)  1MB



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Cape Codders Take Down Parking Lots, Put Up Paradise

14 June 2013

4 COMMENTS

Cape Cod, Massachusetts

May 28-29, 2013

On Cape Cod, the 15-town peninsula jutting off of mainland Massachusetts, ‘pahking lots’—or *parking lots* as they are known by some—are a big deal.

“In the off-season, it’s a daily routine for people to grab a newspaper, a coffee at Dunkin’ Donuts, a ‘nip’ if they need it from the liquor store next door, and drive down to the Paine’s Creek parking lot to watch the sunset,” said Jim Gallagher, the Conservation Administrator (<http://www.town.brewster.ma.us/committees-mainmenu-29/conservation-commission-mainmenu->

45) for the Town of Brewster. Although Gallagher was mostly joking about the ‘nip’ part, sure enough, as we interviewed him about beach erosion at Ellis Landing, a construction worker pulled his truck up to the edge of the parking lot to eat his lunch facing the waves.



http://adaptationstories.files.wordpress.com/2013/06/dsc_12211.jpg

A local contractor parks his truck overlooking Ellis Landing for a nice quiet lunch break in the off-season.



http://adaptationstories.files.wordpress.com/2013/06/dsc_1174.jpg

Kids help collect stray pavement chunks that used to be part of the Paine’s Creek parking lot.

This popular local pastime, along with critical beach access for summer Cape Cod tourists, are increasingly threatened because many of the Cape’s parking lots are shrinking. Brewster beaches and other sandy shores along the Bayside have been eroding at alarming rates in the past few years. In a normal year, Brewster residents expect between two and three feet of erosion from wave action and storms. However, in February 2013, Nemo, a vicious winter storm, shaved 20 feet of beach off the Brewster shores and those of neighboring towns. According to Gallagher, Brewster has seen an average of 10 feet of beach erosion over the past five years from storms and sea level rise.

“Something is going on,” he told us. “Either we’re in a period of extreme events, or this climate change thing is really happening.”

In Brewster, beach loss has been so severe that portions of both the Paine’s Creek and Ellis Landing parking lots have broken off into the sea. At Paine’s Creek, the Brewster Conservation Commission determined that armoring (<http://coastalcare.org/sections/inform/shoreline-armoring/>) the lot (building a wall in the water around the lot as a stronghold against erosion) was illegal under the Wetlands Protection Act (<http://www.mass.gov/dep/water/laws/ch131s40.pdf>). They decided, instead, to downsize the lot from 45 spaces to six and move it backward, planting 200 ‘sacrificial’ shrubs along the newly exposed beach to help hold the sand in place until the vegetation inevitably washed



(http://adaptationstories.files.wordpress.com/2013/06/dsc_1153.jpg)

The Paine's Creek lot used to hold about 45 cars, but now it holds 6.

away. The construction was funded by an existing grant from the USDA's Natural Resources Conservation Service (<http://www.nrcs.usda.gov/wps/portal/nrcs/site/national/home/>) (NRCS), primarily intended for repairs to a stormwater drain under the parking lot.



(http://adaptationstories.files.wordpress.com/2013/06/dsc_12171.jpg)

Jim Gallagher surveys the work he has to do to fix the erosion (and stormwater) problem at Ellis Landing.

"We did it because we had the grant money. Otherwise, it wouldn't have happened. We piggy-backed," said Gallagher.

Both Gallagher and Steve McKenna, Chair of the Brewster Conservation Commission and the Cape Cod and Islands Regional Coordinator for the Massachusetts Coastal Zone Management Program (<http://www.mass.gov/czm/>), agree that these one-off projects are just band-aids for a bigger problem. "People are in reaction mode right now—they're just starting to think about the long-term things," McKenna said. "No town is thinking about this in terms of a 10-, 20-, or 50-year time horizon."

However, dealing with beach erosion is not new on the Cape. Historically, towns have tried to hold off the problem with renourishment, which involves taking sand from another location to fortify an eroding beach, and hard structures like stone revetments (http://www.coastalwiki.org/wiki/Seawalls_and_revetments) and armoring. But these 'fixes' cause new problems. The construction processes and hard structures can damage natural ecosystems, including fisheries, and renourishment is a temporary solution—especially if a single storm carries away 20 feet of shoreline.



http://adaptationstories.files.wordpress.com/2013/06/dsc_1219.jpg

Homes next to Ellis Landing have implemented some 'hard' solutions to protect against erosion.

Other options exist. Despite the prevalence of band-aid solutions, Gallagher and McKenna also agree that people are starting to realize a need for a long-term plan that considers 'managed retreat' and soft solutions that are gentler on ecosystems. In Brewster, for instance, Gallagher was hoping the Town would purchase an old motel lot across the street from Mant's Landing that could have served as a protected parking lot and beach facility, a little back from the shore. (Unfortunately, a private developer bought the property first.) Gordon Peabody, Director of [Safe Harbor](http://safeharborenv.com/) (<http://safeharborenv.com/>), a local consulting firm based in Wellfleet, promotes several soft solutions (<http://safeharborenv.com/environmental-initiatives/cape-cod-erosion-control/>) to coastal erosion, including placing inexpensive cedar 'shims' in the sand, coconut fiber rolls on old stone revetments, and living shoreline designs composed of salt marshes.



http://adaptationstories.files.wordpress.com/2013/06/dsc_1200.jpg

These homeowners installed their own fences and planted sea grass to help protect their homes from erosion.

As erosion rates increase, some beachfront property owners on the Cape are taking matters into their own hands, incorporating both 'soft' and 'hard' measures. Some have installed innovative ladder fencing and planted sea grasses on their beaches to catch the sand. Others have taken less legal approaches such as protecting their homes with their own stone revetment structures that may violate the Wetlands Protection Act. The structures may also make erosion worse in the long run, disrupting natural sand processes that would build dunes behind the rocks.

"It's a tough situation," said Gallagher. "These people are facing serious damage to the foundation of their home, but these makeshift barriers can cause serious damage to the surrounding ecosystem."



(<http://adaptationstories.files.wordpress.com/2013/06/bathhouse.jpg>)

The new Leed Silver Provincetown Bathhouse under construction. Photo source: <http://www.wickedlocal.com> (<http://www.wickedlocal.com>)

Provincetown, is using a combination of managed retreat and flexible infrastructure to address its ongoing parking lot troubles. Located on the very tip of Cape Cod, Provincetown is a favorite beach spot for 'mainlanders,' and the Herring Cove parking lot is famous for its sunset vistas. After repeated erosion at the lot, the National Seashore Advisory Commission (<http://www.nps.gov/caco/parkmgmt/advisory-commission.htm>) was charged with coming up with alternatives to 'save the sunset.' In addition to moving the parking lot back 125 feet, the Commission decided to rebuild several bathhouse facilities (<http://www.wickedlocal.com/provincetown/news/x846079485/New-bathhouse-nears-completion-at-Herring-Cove-in-Provincetown>) with strengthened hurricane clips that allow a crane to move it back as the sea creeps up the shore.

As storms and sea level rise are expected to continue eating away at the limited land on the Cape, other questions about long-term planning are surfacing. Tom Stone, a Senior Research Associate at the Woods Hole Research Center (<http://www.whrc.org/>), has thought about how expected sea level rise will affect the building of a much-needed sewer system on the Cape. (Currently, more than 90 percent of homes send their wastewater to aging septic tanks.)

"The \$3 to \$4 billion dollar question is, *What do we do about sewers?*" said Stone. "You can't just put sewers next to the beach because of the expected one to two meters of sea level rise in this region."



(http://adaptationstories.files.wordpress.com/2013/06/dsc_1158.jpg)

"I've learned that Planning is not an instant gratification profession. It takes time, but eventually you see the results of your efforts." -Ryan Bennett, Planner at the Cape Cod Commission

The Cape Cod Commission (<http://www.capecodcommission.org/>), a regional planning body, is addressing these longer-term questions about the impacts of climate change. And, small as they may seem, the parking lot projects have prompted many Cape Codders to begin to think about the big climate picture. Residents want to continue to enjoy their beaches—whether it's watching the waves and sunsets from their 'cahs' with a donut and some spiked coffee or venturing out of their vehicles to walk on the sand.

To view more photos [click here](http://adaptationstories.com/photos/) (<http://adaptationstories.com/photos/>).

Posted By: khowagold Category: Adaptation Strategy, Cape Cod MA, Climate Impact, Coastal protection, Hurricanes, Infrastructure improvement, Location, Planning, Retreat, Sea level rise Tags: adaptation, Barnstable, Cape, Cape Cod, Cape Cod Commission, Cape Cod National Seashore, climate change, Counties, Dunkin Donuts, Erosion, Living shorelines, Massachusetts, Nemo, Parking lots, Planning, Provincetown, resilience, Revetments, Seawalls, storms, Sunsets, United States

4 thoughts on “Cape Codders Take Down Parking Lots, Put Up Paradise”

1. alaynahoward

[June 14, 2013 @ 11:36 am](#)

Love the title! And the soft solutions sound really cool, I'm interested to see if you encounter similar ideas regarding coastal erosion on other shorelines, particularly on the west coast. Great article Allie and Kirsten, keep it up!

[Reply](#)

2. Andrew Howard

[June 18, 2013 @ 7:22 am](#)

Great story! Well written and very informative. Reminds me of our visits to the Cape and you playing in the sand.

[Reply](#)

3. Claire

[June 18, 2013 @ 12:55 pm](#)

Really captures the cape spirit! Great article!

[Reply](#)

4. Nancy Edgar-Howard

[June 22, 2013 @ 9:24 am](#)

It is so apparent that something is going on when you see the sidewalks and parking lots crumble time and time again. Good article! Change will happen.

[Reply](#)

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Interns and Volunteers

The Town proposes to hire two seasonal interns to work on these projects during the two years of implementation. We expect to hire college students studying for an environmental degree who are interested in field experience. Primary tasks will be implementation and monitoring of the oyster reef project, and plantings and restoration work at the managed retreat sites (Breakwater and Mants Landings). Additional tasks will be documentation of project tasks via photographs and a regularly updated and public website, and coordination and participation in public outreach events.

The Town will provide seasonal housing for the two interns, and the grant will provide wages and reimbursement for expenses.

Seasonal Internship:

4 months per year (14 weeks) for two years, two interns, 35 hours per week = 1960 hours.

Hourly rate used would be \$14/hour with housing provided by the town as match.

Wages \$27,440

Mileage/expenses stipend = \$1400 (\$25/week per intern)

Total: \$28,840.00

Value of housing is \$1000/month x 8 months = \$8000 (match from Town)

Collaboration and Partnerships.

The Town of Brewster has been working on different project components now for a number of years. These project components and partners, stakeholders and in-kind support and level of review are summarized below. The dollar value of restoration and protection grants that Brewster has received are summarized in a separate Attachment (Leveraging).

Salt marsh and fish passage restoration and protection: In Brewster, four tidally-restricted salt marshes have been restored (Stony Brook, Freeman's Pond, Quivett Creek, and Namskaket Marsh). Fish passage for diadromous fish was restored at Stony Brook and Quivett Creek. These restoration projects involved active participation by many partners including citizens, organizations, local, regional state and federal agencies and private firms. The Stony Brook-Freemans Pond-Lower Mill Pond Fish Passage Restoration Project in particular involved a large number of partners, resulting in Brewster receiving a Coastal America Partnership award in 2011. Some of these partners are listed below:

- NOAA Habitat Restoration Center
- NOAA Community-Based Restoration
- U.S. Fish & Wildlife Service
- USDS Natural Resources Conservation Service
- FishAmerica Foundation
- Gulf of Maine Council for the Environment
- Massachusetts Division of Ecological Restoration
- Massachusetts Office of Coastal Zone Management, Wetlands Restoration Program
- Massachusetts Bays Program
- Massachusetts Division of Marine Fisheries
- Massachusetts Corporate Wetlands Restoration Program
- Massachusetts Riverways Program
- Brewster Conservation Trust
- Brewster Chamber of Commerce
- Brewster Alewife Committee
- Town of Brewster departments
- Association to Preserve Cape Cod (APCC) and its volunteers (salt marsh monitoring, herring run monitoring)
- Compact of Cape Cod Conservation Trusts
- Conservation District of Cape Cod
- Cape Cod Museum of Natural History
- Woods Hole Group, Inc.
- Americorps of Cape Cod

Oyster Reef project: For Brewster's initial pilot to construct an oyster reef at Breakwater Landing Beach, a key partner was the Barnstable County Extension's Shellfish Biologist. For this proposed pilot project to install an oyster reef at Paines Creek Beach salt marsh, a key partner will be Dr. Mark Faherty, senior biologist with the Wellfleet Audubon Sanctuary, who has pioneered the creation of oyster reefs to foster biodiversity on Cape

Cod. For this project he was awarded a research and planning grant from the Mass Bays Program (a project summary and Dr. Faherty's final report are posted at: <http://www.mass.gov/eea/agencies/mass-bays-program/grants/mbp-r-and-p-grants-fy12.html>). Another partner will be the Association to Preserve Cape Cod, which will monitor the salt marsh using a state-approved protocol and QAPP. APCC has provided salt marsh monitoring for restoration projects beginning in 2003.

Coastal Resiliency Planning: Brewster has initiated parts of this process, and our partners are conducting their studies that will contribute to Brewster's proposal. Work and partners include:

- Provincetown Center for Coastal Studies, which is developing and testing a method to determine the sediment budget for Truro and Wellfleet. This method will be applied to Brewster's coastline to identify areas where net sediment flux (sediment budget) indicates either long-term erosion, accumulation or stasis.
- Mass Bays Program: PCCS was awarded a research and planning grant in 2012 to conduct the study named above. The Mass Bays Program supports climate change adaptations to benefit coastal ecosystems (see <http://www.mass.gov/eea/agencies/mass-bays-program/>).
- Association to Preserve Cape Cod: APCC is partnering with the U.S. Geological Survey, the Cape Cod Commission, the Nature Conservancy and others to have USGS model the effects of sea level rise on the mid-Cape's groundwater system (see APCC webpage on project at: <http://www.apcc.org/sealevelrise/index.html>). Then APCC and partners will provide outreach and adaptive measures to promote community adaptation to impacts on water resources and to promote protection or adaptation of water-dependent natural resources. This work will dovetail with and complement Brewster's proposed task.
- Town of Brewster's Integrated Water Resources Plan: a citizen water quality committee and Town staff (including the Town Planner) are working with a consultant to develop this integrated plan to protect drinking water, wetlands and water bodies, and manage stormwater and wastewater. The Town's work towards this plan is described at <http://www.town.brewster.ma.us/committees-mainmenu-29/comprehensive-water-planning-committee> .
- The Town will coordinate with the Cape Cod Commission which is developing a Cape-wide coastal resiliency assessment tool in a separate proposal.

Managed retreat at Town beaches: Brewster's success with its first managed retreat project (relocating Paines Creek Beach parking area and restoring beach and dune) was made possible through the Town's active outreach to residents and citizens of Brewster and local, state and federal officials. See an article entitled "Cape Codders Take Down Parking Lot, Put Up Paradise" posted at <http://adaptationstories.com/2013/06/14/cape-coddors-take-down-parking-lots-put-up-paradise/> .

Stormwater management: Brewster has worked with many partners to identify, assess and remediate stormwater drainage into Brewster's coastal watersheds. These include:

- Massachusetts Office of Coastal Zone Management, which provided a Nonpoint Assessment grant to prioritize stormwater discharges for remediation, and a Coastal Pollutant Remediation grant to design stormwater treatment for a discharge into Stony Brook;

- Massachusetts Department of Environmental Protection (DEP) provided a 319 grant to treat stormwater runoff into Stony Brook, and a 604B-ARRA planning grant to plan stormwater designs.
- Association to Preserve Cape Cod and the Mass Bays Program assisted with grant-writing to obtain stormwater grants;
- Cape Cod Conservation District provided an ARRA grant to remediate the stormwater discharge at Paines Creek Beach;
- USDS NRCS assisted with design and project management of the Paines Creek Beach stormwater project.

Open space and habitat conservation: Nearly one-third of Brewster's land area is preserved as open space for conservation and habitat. These investments in protecting land and water are an important factor in raising Brewster's coastal resiliency. Millions of dollars have been provided by the Brewster Conservation Trust, Brewster town residents through Town Meeting votes, and state and federal agencies for land preservation.

Level of review of this project: This project has been reviewed by Town of Brewster Town Manager, Town departments, Provincetown Center for Coastal Studies, Association to Preserve Cape Cod, the Mass Bays Program, Wellfleet Audubon Sanctuary, and other local, state and federal elected officials, as evidenced by letters of support for this project.

In-kind support: APCC and the Mass Bays Program will provide \$11,000 in in-kind support to assist the Town with project management and outreach, and another \$10,000 in in-kind services to monitor restored beaches and dunes and to monitor salt marsh.

The Town of Brewster will use staff (Chris Miller, Director of the Natural Resources Department) as the project team leader for the Town (2000 hours/\$44,000). The Town will also provide living space for two summer interns for two summers to support the grant (approximate value \$8000). Estimated volunteer time working on plantings and dune restoration at Mants and Breakwater projects is approximately 300 hours (\$22/hour = \$6,600). Other volunteers working on the oyster reef would provide another 300 hours over the two year period (\$6,600).

Many other Town staff will have substantial involvement throughout the project, such as the Department of Public Works Superintendent, the Town Administrator, the Town Planner, Conservation Administrator, etc.

We estimate the value of services provided by the Town (In-kind services) to be over \$80,000 over the two year grant period.

Monitoring to evaluate success of projects

- a) Monitoring of restored beaches and dunes at managed retreat sites. Pre- and post-restoration monitoring of the beach and dune at managed retreat sites (Breakwater Landing, Mants Landing, others) will be conducted for the purpose of documenting success of restoration work and to identify any issues or problems that need to be addressed in order to assure successful restoration of habitat. Monitoring will include the following activities:
- Photodocumentation of beaches and dunes using georeferenced photographs, before and after restoration and during construction activities.
 - Monitoring of restored dune vegetation for two growing seasons, using plots of 1 meter-square to measure percent cover, plant height and species.
 - Monitoring of avian use of the sites, to be conducted using a survey methodology that consists of morning and evening bird counts (based on visual and auditory information) performed by experienced birders (there are many volunteers with this skill).
 - Monitoring of other wildlife usage, to be conducted using a night-time infrared motion-detecting camera or video camera to be installed in secure locations.

Budget: Labor will be provided by the Town's interns (to be hired under this grant) volunteers and staff. Direct costs total \$5,000 (e.g, \$1,000 for infrared-motion-detecting cameras, \$3,000 for field equipment and supplies, \$1,000 for mileage to and from monitoring sites). **\$5,000.00**

In-kind: APCC will provide an in-kind match of \$5,000 for photodocumentation.

- b) Oyster reef monitoring. The growth and development of the oyster reef will be monitored utilizing a procedure developed by Dr. Faherty and available at <http://www.mass.gov/eea/agencies/mass-bays-program/grants/mbp-r-and-p-grants-fy12.html>). Monitoring parameters include water quality, nekton, avians, oyster size and density, and disease-testing for Dermo and MSX. Monitoring oyster reef effectiveness in reducing erosion, change in water quality, and establishment of more diverse habitat will likely take more than one season. The Town of Brewster is dedicated to the success of this project and will continue photo monitoring of the shoreline and reef. Reduction in erosion will be monitored using photography before and after, including establishing reference stakes in the study area versus reference areas to monitor sediment movement, growth or reduction in fringe marsh deposits, and general sediment transport. The Town will continue periodic monitoring of flora and fauna that are attracted to the area after the oyster reef is established, including photo surveys.

Budget: Monitoring, disease-testing, reporting over 2 years (contractual): **\$25,000**

- c) Salt marsh monitoring. The adjacent salt marsh will be monitored to evaluate how the salt marsh reacts to the presence of the oyster reef. Monitoring parameters will include salt marsh vegetation (species, per cent cover in 1-meer-square plots, plant height, whether salt-marsh or brackish-species), water quality (pH, temperature, total dissolved solids, salinity, conductivity), nekton (i.e., fish, invertebrates), avians, and photographic documentation of salt marsh vegetation, erosion/accretion and other

features using georeferenced digital photography. The Town will contract with the Association to Preserve Cape Cod to perform pre- and post-restoration monitoring of the salt marsh. APCC will also monitor the nearby Freeman's Pond salt marsh that was restored in 2013, as an in-kind match. Freeman's Pond salt marsh is relevant to this task because the experimental oyster reef and salt marsh are located seaward of the barrier beach that protects Freeman's Pond from direct storm waves and inundation. APCC has been conducting salt marsh monitoring since 2003, for coastal restoration agencies such as the Massachusetts Division of Ecological Restoration, Gulf of Maine Council for the Marine Environment, Cape Cod Conservation District, and others. Salt marsh monitoring is conducted by APCC using a state-approved Quality Assurance Project Plan (QAPP). More information on APCC's salt marsh monitoring program is posted at APCC's webpage on salt marsh monitoring, at <http://www.apcc.org/saltmarshprogram/index.html>.

<u>Budget:</u> Salt marsh monitoring for two years (APCC)	
432 hours of labor over 2 years:	\$18,720
Direct costs (mileage, equipment, materials, supplies);	<u>\$4,280</u>
Total:	\$23,000

In-kind: APCC monitoring of Freeman's Pond: \$5,000

d) Fiscal Monitoring	
Perform required Federal audit (2 years at \$5000/year)	\$10,000

Total Monitoring budget: **\$63,000**